TOPICS OF THE MONTH

Mutual aid in Communist chemistry

THE Soviet Union is finding that it pays dividends to co-operate with other Communist countries in the chemical field. Thus, during seven years of co-operation with Eastern Germany in this field, the U.S.S.R. has been able to cut capital expenditure in the construction of potassium undertakings by between 6½ and 7 million roubles. The use of German technical experience in the construction of new chemical-fibre plants will yield a saving of about 100 million roubles. Several million more will be saved through the use of technical specifications provided by Czechoslovak chemists.

Plans for the joint solution of major problems of the chemical industry in the Communist countries have now been drawn up, as was revealed by Mr. G. Uvarov, vice-chairman of the U.S.S.R. Council of Ministers' State Committee for Chemistry, in an article in *Izvestia*. Priority is to be given to problems concerning synthetic fibres, rubber, mineral fertilisers and plastics of various kinds. Mr. Uvarov stresses that this kind of co-operation between the various states of the Communist bloc is promoting more rapid progress and is saving a great deal of time.

Prospects for chemical engineers (and 'engineeresses')

HOW much do chemical engineers earn? As can be seen from vacancies advertised in newspapers and in the technical press, salaries vary widely according to the size of the firm, the nature of the industry and the kind of work (design, development, construction or operation) for which the vacancy exists. However, a booklet published by the Institution of Chemical Engineers takes a courageous stab at setting out an approximate scale of salaries, noting, for instance, that five-year student apprentices are paid about £5 10s. to £6 10s. a week at the age of 18, rising to £9 or £10 a week at 23. In a number of large companies, starting salaries range from about £600 p.a. for 'pass' graduates in chemical engineering to about £800 or £900 for an honours graduate with a postgraduate qualification such as PH.D.

The competent chemical engineer may well double his salary by the time he has reached his early thirties, but after that there is a great variation in the maximum salary paid. This is not surprising since, as the booklet points out, chemical engineers are to be found in the higher administration and in the direction of research and development in many companies.

The Institution's new booklet, entitled 'Education and Training in Chemical Engineering,' brings together in one tidy and useful little publication various leaflets and other material released by the Institution from time to time. It includes a brief comment on the subject of women chemical engineers, vacancies for whom are limited at present as industry is reluctant to employ women in plant management. It is prophesied that opportunities for women in chemical engineering will increase and that, as employers become more used to the idea of calling on both sexes to obtain the qualified people they need, women will gradually attain equal status with men, as in other professions.

Not-so-easy manganese

MANGANESE, that important constituent of steel, is the subject of a great deal of hard thinking and hard work in various parts of the world in trying to make its production economical. From India recently came news of success with a process for producing manganese electrolytically from low-grade ore—a quest which has kept Indian research workers busy for many years past (see CHEMICAL & PROCESS ENGINEERING, 1954, **35** (3), 89). It is reported that the new process developed at the National Metallurgical Laboratory, Jamshedpur, ensures production of metal of 99.95% purity from low-grade ores. If so, this is an important advance for India, whose total reserves of manganese ore are estimated at 150 million tons—60 million tons of this high-grade and the rest low-grade. Nearly a million tons of high-grade ore are exported annually or utilised for ferro-manganese production, while the low-grade ores are mostly dumped as waste.

In the U.S.A., which is not so well off in workable manganese deposits, no new development comes to brighten the picture of the country's heavy reliance on imports. Many attempts have been made to develop an economical method of concentrating low-grade manganese and, although results have been encouraging, no universal treatment has yet come to light. Some methods have been direct smelting of low-grade ores, leaching and oil-emulsion flotation. Electrolytic production, too, has featured at some U.S. metallurgical works and, indeed, it was the American advances in this field that provided the inspiration for the initial efforts in India.

Normally, as is revealed in a recent bulletin of the Colorado School of Mines, the United States can supply about 10% of its manganese requirements from domestic deposits. The remainder must come from other areas of the world. Since the U.S.S.R. contains about 60% of the world's manganese in large, low-cost, high-grade mines, it could be the world's largest exporter. Before 1948, more than a third of U.S. imports came from the U.S.S.R. but, the report says, shipments have now been completely stopped, apparently in retaliation to the U.S. embargo on export of strategic materials.

One of the world's biggest sources of manganese is West Africa and the opening of a new manganese

mine there to be operated at only about 50% of its productive capacity gives some idea of the trickiness of the manganese market today. Some questions were asked by the shareholders of the company concerned, South African Minerals Ltd., at its annual meeting. The chairman and managing director explained that the mine was to be a 'captive' one, owned by the United States Steel Corporation. When demand was good such mines supplied the major needs of their consumer-owners and when demand was low they put manganese on to the market in competition with 'free' producers. He pointed out that it would be uneconomic to increase the mine's production beyond the 50% planned. Other large producers had not been able to find a market at all; as it was, the 50% production would enable the mine to continue development, putting it in a stronger position should market conditions change.

Pig iron from scrap

ALTHOUGH the use of electric-arc furnaces for producing steel from scrap metal is quite common today, the production of pig iron from reclaimed scrap steel is a departure from normal practice. At their foundry department at Hollinwood, Manchester, Ferranti Ltd. will be doing just this, using scrap which consists basically of croppings from transformer laminations and other mild steel. Ferranti will thus make a big saving in cost, as pig iron was formerly bought from an outside source.

The furnace to be used is a *Birlefco* 1,600-kva. electric-arc unit of 3 tons' capacity. Besides pig iron, *Nomag* non-magnetic grey cast iron, spheroidal-graphite iron and another type of cast iron will be produced.

Geothermal power progress

A SPOT of bother with the Wairakei geothermal power station in New Zealand raised a suspicion that the project would not come up to expectations. But all is well; the trouble was with the ancillary and not the main plant. The main machinery is in perfect condition after six months' running and this suggests that the scheme will be an outstanding success. So said Mr. A. E. Davenport, general manager of the New Zealand Electricity Department, at a conference of electrical supply authorities, and he said his Department was confident that the station, the first of its type in the British Commonwealth, will be in full production on schedule. He pointed out that they had been running an incomplete station and certain materials had not arrived on schedule. The recent shut-down was to allow the installation of automatic equipment which has eliminated the need to dash from the powerhouse to the well field in the event of any breakdown.

Power production from Wairakei is, however, behind schedule, according to the N.Z. Minister of Electricity. He announced that the station was now generating 16,000 kw.

Transatlantic grinder

WE hear so much about American equipment and processes being manufactured in Britain and Continental Europe that it makes a refreshing change when things are the other way round. This is the case with the *Vibro-Energy* mill, a British development which is soon to be manufactured under licence in the United States. The mill, described in CHEMICAL & PROCESS ENGINEERING, 1958, **39** (7), 263, effects fine grinding with close control by the use of high-frequency, small-amplitude vibrations. Its makers see it as something that could replace and do a better job than the ball mill in many industrial applications. It can also make an efficient job of grinding many materials which are now dealt with by fluid-energy, chemical precipitation and similar methods.

The *Vibro-Energy* mill is a joint development of Wm. Boulton Ltd. and W. Podmore & Sons Ltd., and these two firms have now entered into contract with the Southwestern Engineering Co. of Los Angeles, California, for the manufacturing and marketing of the mill in the United States and other parts of the Western Hemisphere.

According to Mr. E. M. Breeze, managing director of Wm. Boulton, the new mill can cut grinding time as much as 75%, while space requirements are only one-sixteenth of a ball mill's for a comparable output. Less contamination of the product, controlled heat, easier sampling inspection and easier draining and cleaning are among other advantages claimed.

Swedish pulp drier in U.S.A.

THE new $38-million sulphate pulp mill of Bowaters Carolina Corporation at Catawba, South Carolina, U.S.A., includes a pulp drier of Swedish origin which, utilising a stream of heated air at very high velocity to convey the pulp sheet through the machine, is the first of its type to be used in North America. Bowaters say that this machine has proved to be superior to machines in which the sheet is conveyed by mechanical means, since the air is used to convey the sheet and dry it at the same time. The high velocity of the air also leads to a higher specific evaporation capacity with a subsequent reduction in drier size and higher operating speeds.

A feltless wet machine rated at 400 tons/day feeds the drier and is designed to handle bleached, semi-bleached and unbleached pulp. When operating on bleached pulp, stock is pumped from a 75-ton, high-density tank through a consistency regulator to a surge chest. From this chest the pulp is pumped through a consistency regulator and magnetic flow-meter into a fan pump which pumps dilute stock through a set of centrifugal cleaners to the sheet former headbox, from which stock enters the sheet former. The sheet is removed from the face of the forming cylinder by means of a rubber couch roll. A shredder conveyor is mounted at the discharge of the forming cylinder to repulp the sheet when threading the wet end of the pulp drier. The pulp passes through two

presses, after which it enters the drier, where it makes 17 horizontal passes for a total sheet length of about one-third of a mile inside the drier.

To circulate the hot air in the drier 120 fans driven by 12-h.p. motors have been installed in the drier housing. The fans are so arranged that one fan at a time may be removed for maintenance with no loss of production. Drive rolls are located at the end of each pass within the drier. The drive and bearing supports for these drive rolls are mounted outside the hot air zone for ease in maintenance and lubrication.

Heat for the drier is provided by steam coils which are supplied with 150 p.s.i.g. saturated steam. An economiser is mounted on the roof of the drier building to recover the major portion of the exhaust heat from the drier. This heat is used to preheat the fresh air make-up to the drier and the heating of water for the sheet former. To regulate the amount of tension in the sheet, a hold-back press has been located between the drying machine and the cutter.

The pulp drier machine is driven by a 200-kw. motor-generator set with d.c. drives mounted on each piece of equipment. Control devices have been provided to measure and control the tension between each section of the drier.

Keep standards moving

THE need for keeping engineering standards constantly under review and up to date was stressed by Sir Christopher Hinton, Chairman of the Central Electricity Generating Board, in a recent speech in London. He recalled incidents in his earlier career with Brunner Mond and I.C.I. and his war-time connections with the Ministry of Supply. These and subsequent experiences had convinced him that standards should not remain static or unaltered for long periods. And, to be really effective, they should not be too wide in range or scope.

He appreciated the work and difficulties of the British Standards Institution, who often had to prepare British Standards to satisfy many user and manufacturing requirements. Attempts to satisfy all these demands can, however, reduce the value of standards in important applications.

Sir Christopher was speaking at the annual luncheon of the Engineering Equipment Users' Association which, he said, was successfully carrying out the type of standardisation work he had originally contemplated when with I.C.I. A suggestion he had made at that time, that I.C.I. might approach a few other organisations with the aim of promoting or adopting joint standards, had proved unacceptable on the ground that such action might be regarded by some as forming a ' buyers' cartel,' which would lead to the setting up of an opposing ' sellers' cartel ' to the detriment of both sides. The growth and success of the E.E.U.A. had shown that such fears were unjustified. Nevertheless, he felt that the possibility of them arising again should be kept in mind by the Association when considering extension of its membership and the scope of its future work.

New fields for Canadian effluent-disposal process

A SIMPLE, very rapid and relatively cheap method for dealing with sanitary sludges and many types of industrial pollutants has been undergoing successful community-scale testing at Beaconsfield, Quebec, Canada. This is a residential suburb of some 7,000 population about 15 miles from down-town Montreal and fronting on Lake St. Louis, a wide section of the St. Lawrence River. The community, previously dependent upon individual cesspools and septic tanks, is completing installation of a network of sewer lines and a primary sewage treatment plant.

The new feature of this treatment plant is the replacement of conventional bacterial digestion and drying of the settled raw solids by a method known as the *Atomized Suspension Technique* (or A.S.T., for short). This method destroys odours and bacteria in this material and burns it to a harmless inorganic ash in less than a minute. A.S.T. has been handling the sludges from Beaconsfield for several months and has been provisionally accepted by the Town Council as a permanent part of the primary treatment plant.

The A.S.T. procedure was developed by the Pulp and Paper Research Institute of Canada during research on the recovery of chemicals from the spent liquors of pulp mills. It is now evident that A.S.T. may also be applied to many other types of effluent from industrial plants, to the primary processing of chemicals and ores to the drying of foodstuffs and pharmaceuticals and, perhaps, even to the conversion of sea-water into fresh water.

The A.S.T. reactor is essentially a tower the wall of which is kept at a high temperature. When a slurry or solution is atomised into it, the moisture of the droplets flashes into superheated steam. This becomes the carrier vapour, as the evaporating droplets move down the tower. Part of the way down, all the moisture has been converted to steam and the solid particles are suspended in an essentially non-turbulent vapour of their own creation. As this suspension continues down the reactor, various kinds of physical and chemical reactions can be induced, one after another, and all in a few seconds. For example, if the solids are organic materials, a small amount of air can be introduced to bring about combustion.

Improved control of fluidised beds

THREE research workers of the United Kingdom Atomic Energy Authority have devised apparatus which is claimed to give more trouble-free and accurate indication of conditions prevailing in fluidised-bed processing equipment than earlier probe devices based on electrostatic or pneumatic systems. The new apparatus measures electrically the heat-transfer coefficient within the fluidised bed in the region of a heated probe and thus gives an indication of the conditions prevailing around it.

So far, instruments intended to record changing conditions of fluidisation have often been limited in their use to materials with low electrical conductivity

and have tended to clog with the materials being processed. Furthermore, in many cases, the probe used is of necessity so large that it causes perturbations in its vicinity, though uniformity exists throughout the rest of the bed. Other types of apparatus are too prone to mechanical shock damage.

The new apparatus, devised to avoid these pitfalls, consists of an electrically-heated probe maintained at a higher temperature than the bed and means to measure the power fed to the probe to maintain it at constant temperature. Any perturbation in the fluid surrounding the probe will be reflected by a fluctuation in the power fed to it.

Electronic control for German refinery

IN the eight years since the world's first electronic process control system for an oil refinery was installed —at Llandarcy in South Wales—considerable further progress has been made in applying this technique to the petroleum and petrochemical industries. A large number of engineers and executives, including some from the petroleum, chemical, gas and steel industries as well as from the plant-construction and instrument fields, had an opportunity of seeing how far electronic control methods have progressed when Evershed & Vignoles Ltd. invited them to inspect a large control panel and desk for installation at the Dinslaken oil refinery of the B.P. Benzin & Petroleum A.G., Germany.

The control desk contains the process controllers, indicating and recording facilities, supervisory instruments and manual control provisions for two crude-distillation units, a *Hydrofiner*, a catalytic reformer and a re-distillation unit. Thus it accommodates within a remarkably small space every one of the 120 separate control loops which are required for the operation of the 100,000-bbl./day refinery.

The most impressive feature of the panel, perhaps, is the extensive use of 'in-line scanners' so that, during satisfactory operation of the refinery, an unbroken shadow line is presented to the operator and any break in this line immediately pinpoints the unit in which a deviation from desired conditions has occurred; it also gives an indication of the magnitude and direction of this deviation.

An unusual feature of the control panel is the provision of only two recorders for each panel (apart from the recorders employed for standard temperature measurements), each permitting the recording of plant parameters from 16 different points distributed widely throughout the refinery, through a simple plug-in selection system. With this arrangement it has been possible to satisfy in a most concentrated form the comprehensive instrumentation and recording facilities required during start-ups, etc., occupying only a minimum of panel space, and achieving a panel layout of admirable simplicity.

Selection of temperature measurements to accommodate the multiplicity of information required at the central control room is provided by a switching system based on telephone-type keyswitch boards mounted on each control desk, so that, despite the relatively small number of recorders, comprehensive coverage is attained. In general, the temperature-measuring circuits consist of a thermocouple feeding into a potentiometric recorder *via* the switchboard. There are, however, certain loops where d.c. amplifiers are employed to convert the thermocouple output voltage into a signal suitable as measured value input for a process controller.

PTFE pipework achievements

THE advantages of PTFE as a material of construction for anti-corrosive service are well known, but the problems which plastics manufacturers have to overcome so that the material can be made available in the desired forms have been less widely publicised. In a lecture delivered in London recently Mr. T. R. Thierry, of the Resistoflex Corporation, U.S.A., went over some of the snags that had been encountered in producing pipe linings and components in PTFE, and some of the results that had been achieved.

He discussed, for instance, the factors which, coupled with the high bulk density of PTFE powder, generally limit extrusion of tubes in the relatively larger sizes required for lining pipe to heavy-wall thicknesses averaging about $\frac{1}{4}$ in. Despite the fact that three different types of PTFE powders, according to the degree of granulation or particle size, have been developed, all attempts to extrude thinner wall thicknesses, down to approximately $\frac{1}{16}$ in. in pipe sizes of 1 in. and larger, have been only partially successful owing to intermittent porosity. As a result, all three of these powders are generally limited to preforming into relatively thick sections such as the conventional range of sizes of ordinary sheets, rods and tubes.

However, a very fine grade of PTFE has been developed by Du Pont which is compounded with lubricants and a very small amount of carbon black is added. It is claimed that this method results in uniform products of consistent density with, usually, twice the tensile and compressive strength, ductility or flex-life of those obtained by conventional processes.

A suitable material for lining pipe having been developed, it remained to find a way of getting the lining to stay locked inside the pipe over a wide range of process temperatures, and with it some means of overcoming the thermal expansion difference of approximately ten to one between the PTFE liner and the steel pipe. According to Mr. Thierry, this problem has now been solved to the extent that the liner is under controlled tension regardless of size or length and, as the temperature of the process stream increases, all the way up to 260°C., the liner simply tends to overcome its inherent tension without elongating. At the same time, the liner resists collapse under negative pressures by attempting to expand diametrically within the housing. This only causes the liner to lock itself more tightly in place as the temperature increases.

The Resistoflex Corporation's PTFE-lining process is being operated in the U.K. by B.T.R. Industries Ltd.

Economical Production of Sodium Thiosulphate

By F. Molyneux, Ph.D., B.Sc.(Lond.), B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.Chem.E.

Production of photographic-grade sodium thiosulphate ('hypo') at a cost of £17 10s. per ton, compared with an average market price of £34 per ton, is made feasible by the process described.

THE rapid exhaustion of the Le Blanc waste which up to the period of the first world war had provided the raw material for 'hypo' manufacture made it necessary to find a new process for the economic production of this material. The most likely process for the direct preparation of sodium thiosulphate was by the reaction between sodium sulphite and sulphur, according to the equation:

$$Na_2SO_3 + S = Na_2S_2O_3$$

This reaction had long been known and was featured in the textbooks, but, until investigated thoroughly by Hargreaves and Dunningham[1] at this time, the conditions for applying it commercially had not been worked out. As a result of the work carried out by Hargreaves, Dunningham and Hitchens on this reaction and the process variables governing it, a process for commercial manufacture was patented as early as 1915.[2]

In spite of this, however, and although the demand for hypo, though relatively small, was still constant, the process never became established on an industrial scale. The factors contributing to this were many, but the major economic factor remained for a long time that the price of sodium thiosulphate was actually lower than the current price of sodium sulphite and, since the small demand for hypo could be met satisfactorily as a by-product of heavy organic manufacture, the process remained generally in abeyance.

This picture has, however, tended to change recently in that the expansion of synthetic phenol production, based on the old classical fusion process, gave as a by-product large additional supplies of sodium sulphite. Frasch sulphur, after the period of anxiety concerning the extent of reserves, became plentiful and stayed cheap, while expanding usage of sodium thiosulphate in the photographic, oil additives and organic trades placed a heavy burden on existing sources.

With this situation in mind, a pilot plant was set up to investigate the manufacture of commercial hypo, using sodium sulphite, as produced in synthetic phenol manufacture, and commercial Frasch sulphur.

No. of Grammes of Anhydrous $Na_2S_2O_3$ Soluble in 100 g. Water

(*Ref.: 'Handbook of Chemistry and Physics,' 3rd edition*, p. 1602. *Chemical Rubber Publishing Co., Cleveland, Ohio*, 1957)

Temp., °C.	*G./100 g. H_2O*
0	52.5
10	61.0
20	70.0
30	84.7
40	102.6
50	169.7
60	206.7
80	248.8
90	254.2
100	266.0

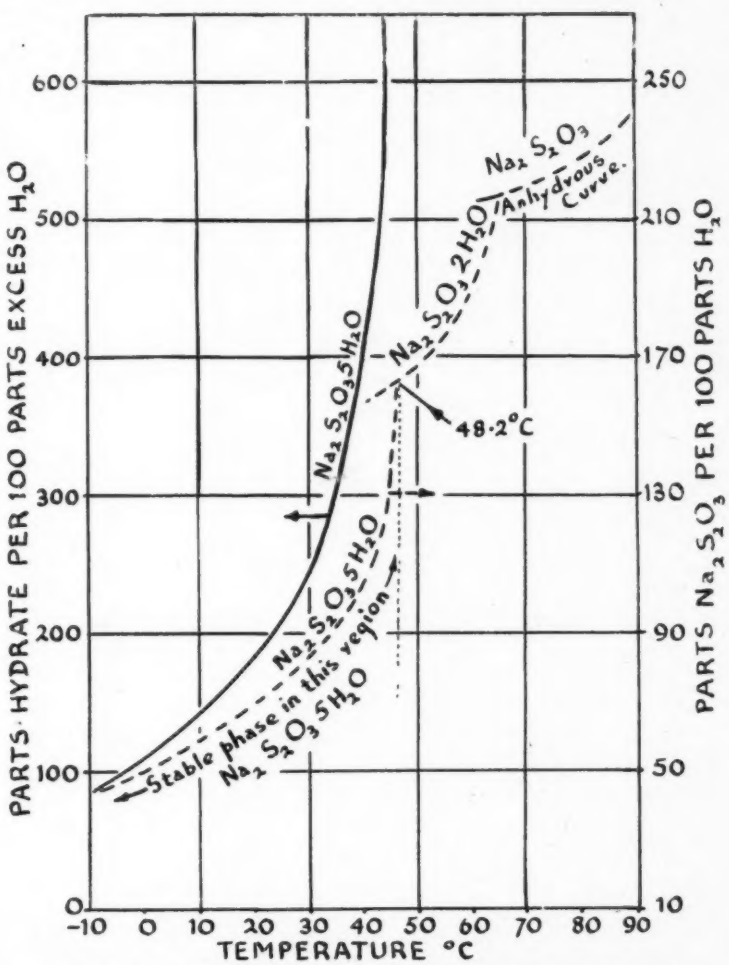


Fig. 1. Solubility data for sodium thiosulphate and the hydrates.

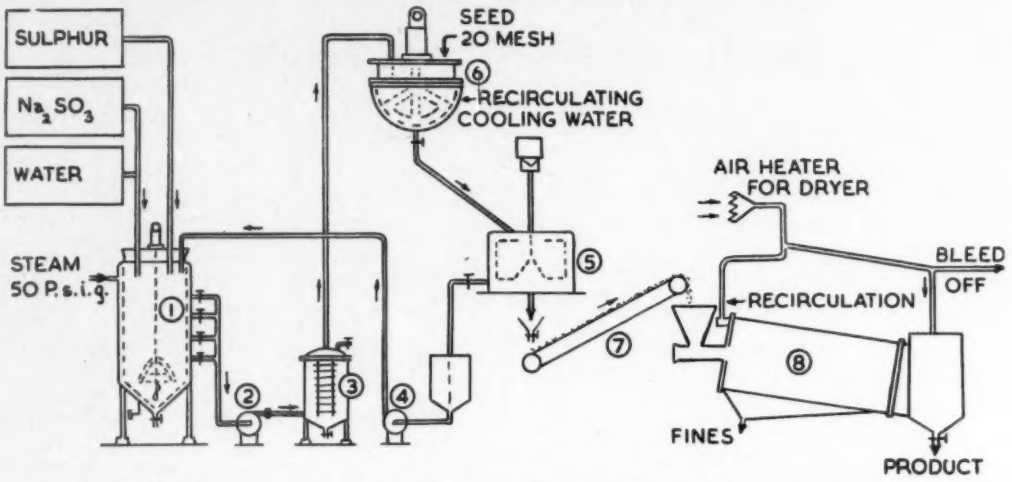


Fig. 2. Pilot plant for producing pure photographic-grade sodium thiosulphate from by-product sulphite and Frasch sulphur.

Process investigation

The experiments of Hargreaves and Dunningham started with sodium sulphite, sulphur and water present in amounts equivalent to a 55.6% w/w solution of $Na_2S_2O_3$, and they showed that initially a saturated solution of sodium sulphite is formed and this is rapidly converted to sodium thiosulphate at the surface of the sulphur.

As the concentration of the thiosulphate increases, that of sodium sulphite decreases and the rate of reaction tends to fall off.

Considering the system Na_2SO_3/H_2O/$Na_2S_2O_3$ at the reaction temperature of 80°C., it could be seen that, at this concentration of thiosulphate in solution, the sodium sulphite solubility decreased and consequently a virtually pure solution of thiosulphate could be obtained. This could also apply to impurities in the sodium sulphite which, being mainly sodium salts, had a similar low solubility product.[6]

It could thus be assumed that it was advantageous to produce as strong a solution of sodium thiosulphate as possible in the initial reaction stage.

Solubility data[3] for sodium thiosulphate and for the hydrates (Fig. 1) show that the most stable hydrate is the pentahydrate (from –10 to 48.2°C.) and that, if crystals of pentahydrate are heated to a temperature of over 55°C., the crystals dissolve in their own water of crystallisation.

It is possible to prepare solutions containing more thiosulphate than is required to form the pentahydrate, but these tend to set as a solid mass on cooling.

Hargreaves and Dunningham recommended, therefore, that the process should be based on the production of a maximum concentration of 62% of $Na_2S_2O_3$, or with more solvent than is required to crystallise out all the $Na_2S_2O_3$ as pentahydrate.

Rates of reaction

The governing feature in any economic process for the manufacture of sodium thiosulphate is the rate of reaction. By the law of mass action this is proportional to the mass of the reacting substances, so that an increase of the concentration of sulphite or sulphur, or both, should lead to an increased rate and equilibrium concentration of thiosulphate being attained at a high figure in a shorter time.

Hargreaves and Dunningham found that, if sufficient excess sulphur is used to form a pasty mass with a mixture of sodium sulphite and water in proportions required to produce a very concentrated solution of thiosulphate, and if this mixture be reacted at 60 to 100°C., then the reaction is completed in 2 hr. or less.

The excess sulphur could then be removed by filtration and used again in the next charge, and it was claimed that, if a solution of thiosulphate is produced by this means, no purification at all is required, even when using the crudest of raw materials, and the excess sulphur can be used after separation in successive charges until the build-up of impurities necessitates its rejection.

The reactions developed by Hargreaves and Dunningham were further investigated by Watson and Rajagopalan[4] who found that, contrary to the results previously reported, the rate of reaction was independent of the concentration of sulphite used, but that with an excess of sulphur equal to three times the amount stoichiometrically required for reaction, then the reaction was complete in 1 hr. at a temperature of 80°C.

This mixture contained only sufficient water to produce a 29% solution of thiosulphate.

The effect of surface-active agents on the rate of reaction has also been investigated with favourable results. No details were actually available, however, concerning the effect of appreciable amounts of impurities in both sulphur and sulphite on the rate of reaction, so that a programme was undertaken with the object of producing pure photographic-grade sodium thiosulphate using by-product sulphite and commercial Frasch sulphur, and investigating process variables under these conditions.

Investigational plant and procedure

The plant consisted of a small reactor of 5-gal. capacity fitted with a variable-speed mixer and with both electric and steam-coil heating or coil water cooling. The remaining items

were assembled around this unit, as indicated in Fig. 2.[7] The following effects of process variables on the rate of reaction, at a constant temperature of 80°C., were studied:

(i) Effect of varying sulphite concentration with the stoichiometric amount of sulphur present. This sulphur was not treated in any special way, excepting in that the commercial sulphur was riddled through a 20-mesh screen and only sulphur passing this was used. In practice, it was found that any lumps present could be quickly broken down to this size using a light timber ram.

(ii) Effect of variation of sulphur excess with a constant concentration of sodium sulphite.

(iii) Effect of varying the size of sulphur particles with a constant sulphite concentration.

Experimental results

The results obtained in this investigation are illustrated in Figs. 3, 4, 5 and 6 and are tabulated in Table 1.

The series (i) experiments were generally in line with Watson and Rajagopalan predictions and, as would be expected from a heterogeneous reaction of this type, these indicated that rate of reaction was substantially independent of sulphite concentration.

Series (ii) experiments indicated that the rate of reaction was generally proportional to the excess sulphur present and it was found that, with the untreated sulphur used, and with an excess sulphur amounting to 200%, the reaction could be completed in 4 hr. to produce a solution containing 50% sodium thiosulphate.

Series (iii) experiments repeated this more successful run, but using 200% excess sulphur, the sulphur being ground to flour in a pebble mill.

In addition to the reaction rate being increased so that the reaction is complete in 2 hr., the graph is notable in that there is no sudden increase in rate of reaction at approximately halfway through the reaction, as is so noticeable in the series (ii) experiments.

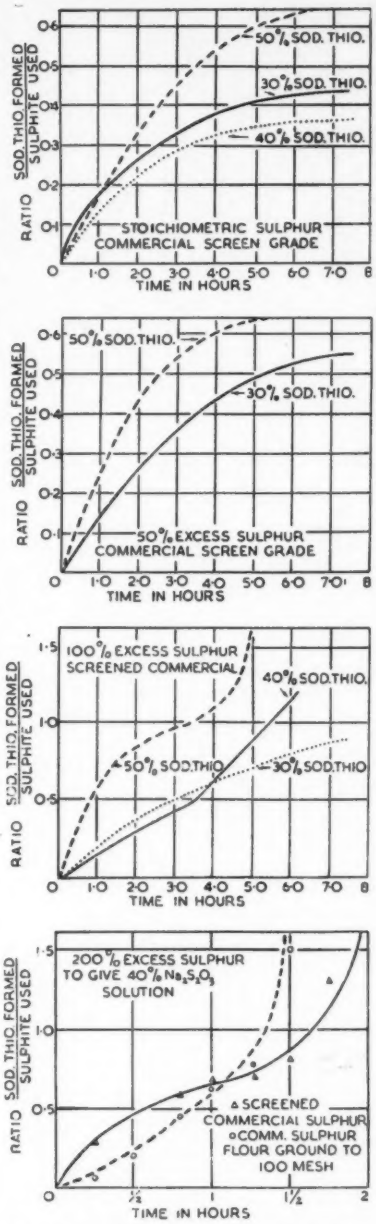
This can be attributed to the breakdown of the sulphur and its solution in sulphite when the particles have attained the size approximating to the particles of sulphur flour produced in series (iii).

It was, however, considered that the economics of sulphur reduction precluded its use in a low-cost product, as is thiosulphate, and further work proceeded using the untreated sulphur and the data of the series (ii) experiments.

Table 1. Experimental Results, Effects of Variables on Rate of Reaction

Ratio: $\frac{\text{Thiosulphate formed}}{\text{Sulphate used}}$

Time hr. min.	Final thiosulphate concentration 30%	40%	50%
Series (i): With stoichiometric sulphur			
30	0.101	0.114	0.138
1	0.200	0.227	0.154
1 30	0.246	0.224	0.388
2	0.280	0.345	0.333
2 30	0.370	0.285	0.526
3 30	0.489	0.352	0.550
4	0.398	—	0.609
4 45	0.432	0.357	0.578
Series (ii): With 50% excess sulphur			
30	0.089	0.055	0.077
1	0.151	0.105	0.136
1 30	0.225	0.131	0.254
2	0.145	0.214	0.350
2 27	0.324	0.225	0.527
3 35	0.396	—	—
4	0.317	0.310	0.320
5	0.500	0.550	0.667
6	0.777	0.534	0.883
Series (iii): With 100% excess sulphur			
45	0.26	0.23	0.50
1 15	0.33	0.26	0.54
1 45	0.46	0.29	0.75
2 15	0.38	0.38	0.41
2 45	0.43	0.17	0.40
3 15	1.00	0.43	0.99
4	0.53	0.71	1.18
4 30	0.81	0.83	1.67
5	0.69	0.95	2.70
6	0.80	1.02	0.80



Figs. 3, 4, 5 and 6. Graphical illustration of results of experiments on the effect of process variables on the rate of reaction.

Series (iii) experiments repeated this more successful run, but using 200% excess sulphur, the sulphur being ground to flour in a pebble mill.

In addition to the reaction rate being increased so that the reaction is complete in 2 hr., the graph is notable in that there is no sudden increase in rate of reaction at approximately halfway through the reaction, as is so noticeable in the series (ii) experiments.

This can be attributed to the breakdown of the sulphur and its solution in sulphite when the particles have attained the size approximating to the particles of sulphur flour produced in series (iii).

It was, however, considered that the economics of sulphur reduction precluded its use in a low-cost product, as is thiosulphate, and further work proceeded using the untreated sulphur and the data of the series (ii) experiments.

Separation and crystallisation of sodium thiosulphate

It was found that, at the reaction temperature of 80°C., the excess sulphur rapidly settled to the bottom of the reactor and the supernatant thiosulphate solution could then be quickly run off.

This solution was pumped into a small water-jacketed vessel fitted with a variable-speed stirrer in which the thiosulphate crystallisation could be carried out.

The analysis of the sodium sulphite used was as follows:

	%	
Water	6.2	
Sulphite	86.7	(as Na_2SO_3)
Sulphate	4.57	(as Na_2SO_4)
Free NaOH ..	0.95	
Sodium phenate ..	1.15	
Fe as Fe_2O_3	0.36	

and it was hoped that, in accordance with Hargreaves' experiments, the impurities would remain with the excess sulphur in the reactor. This unfortunately did not prove to be the case with the sodium phenate into solution and crystallised out on the surface of the thiocrystal.

In addition to causing a distinct pink coloration, suggesting a percentage impurity far higher than that actually present, the presence of the phenate caused a distinct change in crystal habit.

It was impossible to produce photographic-grade, pea-size prismatic crystal, the crystal being small and needle-shaped, and thereby having an

extremely strong tendency to set into a solid mass which proved difficult to break by normal grinding procedures, largely because of the strong tendency for the thiosulphate to revert to a solution whenever mechanical work and consequent heat was employed.

Various techniques of adsorption, absorption and liquid extraction were tried on the thiosulphate solution, all without success.

Purification of the sulphite could, however, be achieved without great difficulty either by recrystallisation of the sodium sulphite as the decahydrate, or by slurrying up with methanol and separating the purified slurry of sodium sulphite.

Both these methods were considered uneconomic in industrial practice, the most satisfactory procedure being that of removing the phenate as crude phenol by drying the impure sulphite in a stream of 18 to 20% CO_2 exhaust gas + 80 to 82% N_2 inerts, at a temperature of 700 to 750°C., and condensing the phenol in a jet scrubber supplied with 5% sulphuric acid. The acid is recirculated from a decanter, the phenol being recovered from the top of this. This phenol would actually pay for the cost of purification.

Using this purified sulphite it was found that photographic hypo in pea-size crystal could be prepared.

The crystallisation conditions were the use of 20-mesh crystal seed in a jacketed mixer, the cooling water being recirculated so as to reduce the temperature at the rate of 5 to 10°C./hr. from the inlet crystalliser temperature of between 60 and 70°C. to between 30 and 40°C., at which temperature the slurry of crystal and mother liquor was removed and then, after centrifuging off the mother liquor, the thiosulphate crystals were dried in a rotary drier and screened.

Materials of construction

The small pilot plant used in these experiments was assembled from material immediately available, and considerable corrosion was experienced by the attack of sulphur under moist conditions and at the reaction temperature of 80 to 85°C. on materials as diverse as copper, aluminium, brass, stainless steel and lead.

A cast-iron reactor proved reasonably satisfactory in service, but the increase in iron content of the resultant thiosulphate would render this material unsuitable for commercial production of photographic sodium thiosulphate. The most suitable reactor is a steam-jacketed cast-iron vessel, enamel-lined and fitted with a slow speed agitator.

The reactor, or digester, should be preferably open-topped, since it was found that, commencing with a solution of sulphite and water to give a 30% solution of sodium thiosulphate, and adding 200% sulphur excess over the stoichiometric proportion required for reaction, and at the reaction temperature of 80 to 85°C., over the reaction period of 4 hr. the loss by evaporation resulted in a 50% w/w solution of sodium thiosulphate.

The advantages of this method lay in the fact that the large excess of sulphur is present under dilute conditions, the sulphite is completely in solution, and the viscosity of the solution is low, so that formation of thiosulphate proceeds at a maximum rate. This method of operation secures a high thiosulphate concentration without the disadvantages of a solution which is so viscous that it is unmanageable.

The supernatant concentrated solution of sodium thiosulphate at 50% w/w $Na_2S_2O_3$ has to be maintained at a relatively high temperature, so that pumps, lines, filters, etc., to the crystalliser should be jacketed.

It was actually found somewhat easier to work with a 40 to 45% $Na_2S_2O_3$ solution from the reactor, and with this at an initial temperature of 85°C. it was possible to maintain conditions through the stainless-steel centrifugal pump and stainless-steel *Metafilter* to the cast-iron enamel-lined and jacketed crystalliser, where it arrived at a temperature of 60 to 65°C.

All pumps, lines and equipment, however, required lagging. The crystalliser was fitted with a slow-speed, anchor-type stirrer, also enamel-covered, and revolving at 8 to 10 r.p.m., scraping the sides of the crystalliser.

The temperature is reduced from 65 to 30°C. over a period of 4 to 6 hr., the seed crystal being added when the temperature reaches 45 to 50°C.

The resulting slurry is dropped from the bottom of the crystalliser *via* a chute to a *Hydrofuge*, the surplus mother liquor being spun off and returned to the digester, whilst the clear, colourless, prismatic crystals of photographic 'hypo' go to a combined rotary drier and trommel screen.

The use of laminated phenol aldehyde plastic was found to provide a very satisfactory rotary drier and screen for this operation, and to have none of the defects generally associated with this type of machine.

Analysis

It was necessary to devise some control method of analysis to determine (*a*) the increase in concentration of thiosulphate and (*b*) the elimination of sodium sulphite. Since both sodium thiosulphate and sodium sulphite react quantitatively with iodine, a total iodine estimation was first made to give total sulphite and thiosulphate, the reactions being:

$$2Na_2S_2O_3 + I_2 = Na_2S_4O_6 + 2NaI \quad \ldots\ldots\ldots\ldots (1)$$

$$Na_2SO_3 + I_2 + H_2O = 2HI + Na_2SO_4 \quad \ldots\ldots\ldots\ldots (2)$$

The sulphite was then estimated by titrating the HI formed in reaction (2) against standard caustic, using phenolphthalein as an indicator, and the thiosulphate concentration obtained by deduction of the estimated sulphite from the total.

The finished sodium thiosulphate concentration was obtained by determination of specific gravity, using a Twaddell hydrometer and the tables given by Perry.[5]

Conclusion

Using recrystallised sodium sulphite $Na_2SO_3 7H_2O$ and screened commercial sulphur, it was found commercially feasible to produce photographic-grade sodium thiosulphate at a cost of £17 10s./ton. This compares with an average market price of £34/ton, the only difficulty being that of the removal of sodium phenate from the by-product sulphite, and it was considered that this would only be economically feasible on plant scale at source using the method outlined.

IMPULSE RENDERING

A forthcoming article by Dr. R. Chayen will discuss 'impulse rendering' as a means of extracting natural products from plant and animal material, and as a process likely to find increasing application in the chemical industry.

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A CPE Chemical Engineering Review

SIZE REDUCTION

Part 1.—Theoretical and practical advances in crushing and grinding; new designs, improvements and materials of construction for crushers and grinders, etc.

By R. V. Riley, Ph.D., B.Sc., F.I.M.

THE following article covers size reduction developments reported in the literature since the last review[1] was prepared. On this occasion, as it covers a longer period than usual, and deals with a correspondingly larger number of developments, the article has been divided into two parts, to appear in separate issues. Part 2 will be mainly concerned with the applications of comminuting machinery in various industries, and with equipment for fine grinding.

Ball mill experiments

Bond's 'third theory of comminution' was tested experimentally by Kaunewurf,[2] working with cement clinker in a small ball mill under laboratory conditions. A close agreement was found between theoretical and actual values of the energy required. The grindability of the clinker decreased in proportion to the increase in silica content and it was possible to obtain a 'work index.' Values which indicated relative ease of grinding were 0.94 to 1.21 for cement clinker and, on the same scale, 0.8 for oyster shells, 2.0 for limestone and 2.85 for shale.

The good results obtainable in practice when a ball mill is worked at super-critical speeds has thrown doubt upon the existing theory, namely that crushing and grinding occurred only by localised sliding of the charge in relation to the mill wall.[3] Actual observations made in a glass-fronted ball mill have shown that when running at above the critical speed the charge oscillates within the mill shell, resulting in the formation of a leading edge of the charge which projects above the bulk of the contents of the mill only to collapse (Fig. 1 (*a*)) and fall as a coherent mass upon the lower portion of the charge (Fig. 1 (*b*)).

In this way a heavy blow is delivered upon the charge and not upon the mill wall. The apparent failure of coke to follow Kick and Rittinger's laws when broken during handling was shown by Mott[4] to be the result of fissuring. When a correction was applied, based upon an experimentally determined 'fissure index,' then the expected linear relationship was found to apply. Very strong foundry cokes, having substantially no fissures, required no correction factor in this experimental assessment.

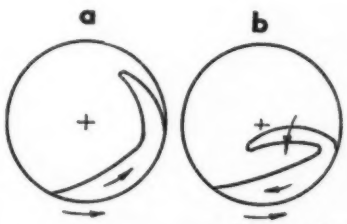
Granulation and ore grinding

Granulation was the subject of a scientific study by a well-known German authority, Prof. Rumpf.[5] Tests were carried out in a granulating disc using limestone of uniform size and the results agreed well with theory.[6]

The nature of the surface of solids and the properties of granules were considered by Peck[7] in a well-illustrated article which described available equipment for all the practical methods of granulating now available to the chemical industry.

The mechanisation of the method of granulating moist, powdered material in a rotating drum was specially studied by Newitt and Conway-Jones[8] and the factors which determine their rate of growth and mechanical strength were discussed.

Tests on the large-scale ball milling of ores[9] in South Africa showed that



[*Courtesy: Nature*

Fig. 1. The two diagrams show how the charge in a ball mill oscillates within the mill shell when operating at one and a half times the critical speed. This throws light on the nature of the grinding process at super-critical speeds (Rose and Trbojevic).

with a modern grinding circuit it was more economical to pump the discharge from the mill to an elevated classifier where the sands could return by gravity rather than to use a scoop feed. At a relatively low rate of air flow through a ring ball mill, an increase in air speed promoted a progressively larger-sized product, but beyond a critical air speed the performance became erratic and the product covered a wide range of sizes.[10] For the particular mill under test, 8 ft. diam. × 11 ft. long, rated at 9.6 tons/hr. of coal, the critical air flow was just under 20,000 lb./hr.

Grinding carbonaceous materials

Experience has shown that, when manufacturing electrode carbon, coal or coke, grists from edge runner mills require less binder than those produced in ball mills, indicating a difference in angularity of particle. Fig. 2[11] shows graphically the difference between the edge runner and ball mill. The effect of the type of mill was found to be consistent and the various types of grinding equipment were arranged in the following order:

(1) Cone crusher — highest angularity.
(2) Ball mill.
(3) Pan mill.
(4) Edge runner—lowest angularity.

This relationship was quite independent of the particular carbonaceous material used in the test, but is a function of the ratio of the primary fracture to the amount of secondary abrasion occurring in the mill.

Jaw crusher improvements

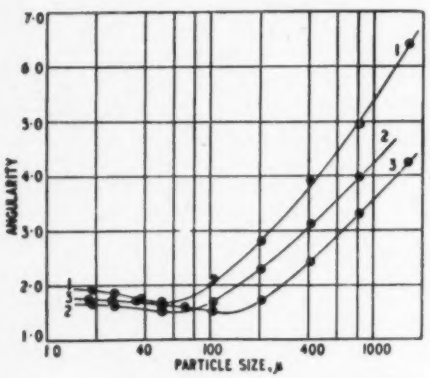
The speed of working of a jaw crusher is improved if the rocks can be kept freely moving through the nip of the jaws. A variable eliptical movement of one jaw relative to the other increases the efficiency of operation, according to patent claims by two separate inventors.[12, 13] Overloading damage may be prevented by the cor-

rect use of resilient rubber between the pressure member and jaw.[14] Other design improvements have been described in the mounting of the jaws.[15–18]

A rather unusual, horizontally-mounted jaw crusher overcame the feeding problem by means of a reciprocating plunger working directly under the feed hopper. The lower jaw was fixed and the upper jaw was made to operate from a separate eccentric drive.[19]

Improvements in the lubrication of the jaw mounting[20] and in the mounting of a wear plate assembly[21] have also been claimed.

An interesting use of the jaw crusher for the primary crushing of limestone is well illustrated in an article[22] describing the new plant recently installed at a Derbyshire lime works. The arrangement of the crushing plant on the side of the hill is shown in Fig. 3. At the head of the plant, on the level of the quarry floor, is the feed hopper to receive the stone from the dumper truck. After passing through the grizzly, the under-6-in. rock is cleaned by a trommel screen of unusual design, having round holes (Fig. 4). The oversize is crushed by a 54 in. × 42 in. jaw crusher set to break the rock to 8-in. size. Interlocked controls are used to ensure safety. The plant produces two sizes of stone: over 5 in. and 5 in. to 3 in., which pass to the kilns, while the stone under 3 in. is discharged. The total capacity is 200 tons/hr.



Curve	Material	Grinding
1	coal coke I	ball mill
2	coal coke I	edge-runner
3	coal coke II	edge-runner

[Courtesy: Society of Chemical Industry

Fig. 2. This graph, in which angularity of particle is plotted against size for coal cokes, illustrates the difference between the edge runner and the ball mill for grinding carbonaceous materials (Amstein and Watson[11]).

Better operation and maintenance for gyratory crushers

To help in the more speedy replacement and maintenance of the crushing members of gyrators, Nordberg Manufacturing Co.[23] have developed locking wedges operating in an annular groove which secure the liners to the shell. A protective plate for the screw securing the crusher cone to the head,[24] and a patent severable head nut[25] for gyratory crushers are also of interest to the maintenance engineer. There have also been proposals for improving crusher head adjustment using screwed rods[26] and hydraulic cylinders[27] and also for improved bearing arrangements.[28]

The severe conditions under which this type of crusher operates makes it necessary to give special attention to the design of bearings, gears, etc., to prevent the entry of abrasive dust. For this reason, a new oil seal[29] and a device for running the machine under pneumatically sealed conditions[30] are of interest. New feeding arrangements[31] and a gearbox design[32] are noteworthy.

Materials of construction for gyratories

Ni-hard, a nickel-chromium white cast iron, has outlasted manganese steel for the 'concaves' of 30-in. gyratories operating on a very abrasive quartzite ore at the Spencer Quarries Inc., South Dakota, U.S.A.[33] The life of these hard-wearing parts was increased four-fold. Whether the liner plates are of cast iron or manganese steel, however, they last longer if properly fitted and it is helpful to 'back' the plates with molten zinc so as to provide a solid mass which can absorb and distribute local stresses.[34] The relatively new spheroidal-graphite cast iron provides a convenient method of making a tough liner which can be surface heat-treated to give a hard martensite surface. The Brinell hardness of the wearing surface is at least 600 and the tensile strength of the back of the liner is 31 tons/sq.in. The recommended composition is: T.C. 3.4 to 4.2%, Si 0.6 to 1.1%, Ni 5.5 to 6.0%, Cr 0.4 to 1.0%, Mn 0.1 to 0.6%.[35]

Hammer mills

Impact crushers are a versatile type of comminuting equipment which always attracts much attention. The hammer mill with its sizing screen has many variants and sundry applications. Thought has been directed to the easier replacement of the sizing screen,[36] the pattern of perforations in the screen,[37] more precise control of sizing[38] and adjustment of the grinding plates.[39]

Sticky materials are being crushed by the impact crusher today; one method is to provide uninterrupted cleaning of the impact surface remote from the area of impact by means of a brush or liquid spray.[40] The impact surface may be rotatable in order to afford a continuously changing point of maximum impact so that the surface wears evenly[41] and is capable of more precise control relative to the rotor.[42] The material discharge from a hammer mill may be assisted by an air or steam blower.[43] Tramp iron, which often causes trouble in a hammer-rotor-type Bradford crusher, may be prevented from entering the hammer chamber by means of a special spider arm.[44]

Other impact mills

Dobreff[45] has described, in a well-illustrated article, various types of impact mill. He has also briefly discussed the laws of comminution which appear to apply to the pneumatic impact mill.

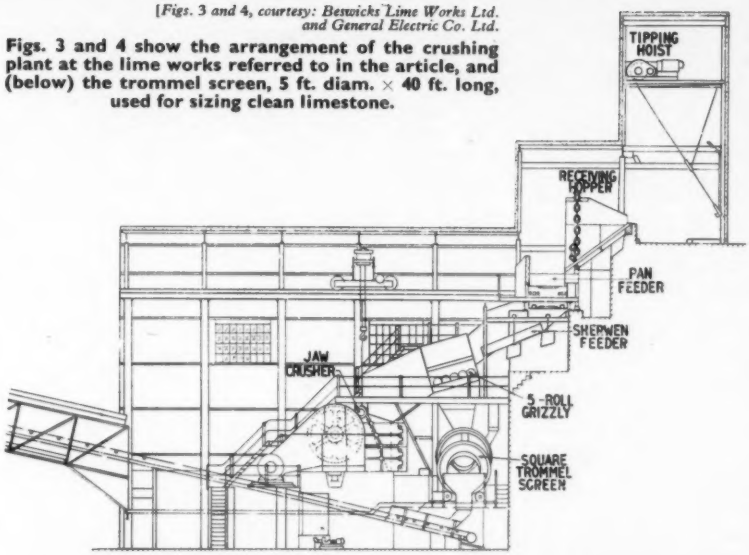
Adams[46] claims an advantage in arranging the linear plates along an arc of a circle substantially at right-angles to the direction of the impelled particle. His mill has a means for aligning the impact plates in this way and provides a simple adjustment to maintain them in position. A feed device for the lateral introduction of the charge into a large impact crusher[47] and an arrangement for securing the wearing plates to the bearer arms[48] are patented.

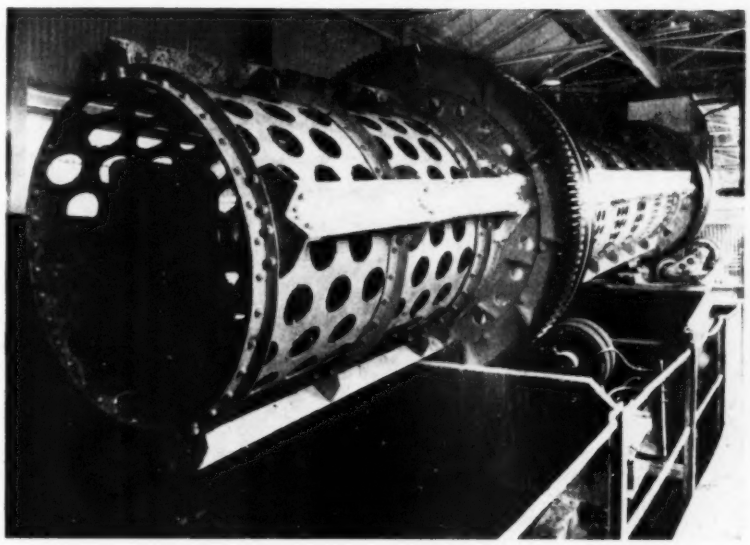
For use in mines, a new impact crusher features a frame which supports the rotor bearings externally of the main casing[49] and another large disintegrator has its complete drive in one closed unit above the base plate.[50] Other modifications to the impact arms,[51, 52] impact plates,[53] heating for both rotor and casing[54] and tensioned wires to break up moist clay[55] are all claimed in German patent literature.

A new American crusher[56] has spaced breaker bars encircling the rotor which in turn are surrounded by a cylindrical grading screen. The latter rotates slowly near the outer casing of the mill and its internally disposed fins convey oversize crushings to the top where they drop through the beater bars to receive a second treatment.

[*Figs. 3 and 4, courtesy: Beswicks Lime Works Ltd. and General Electric Co. Ltd.*

Figs. 3 and 4 show the arrangement of the crushing plant at the lime works referred to in the article, and (below) the trommel screen, 5 ft. diam. × 40 ft. long, used for sizing clean limestone.





Lichtenberg,[57] Borsig[58] and Raab[59] have also claimed improvements in beater mills. The air-swept mill[60] is suitable for crushing brown coal and for minerals of mixed hardness,[61] and it is practicable to arrange the crusher in series with a tube mill and separator.[62]

Coal destined for coking is increasingly being subjected to crushing and grading prior to coking.[63–66] This is one way of offsetting the increasing shortage of good coking coal.

Some recent specialised applications of impact crushing devices include pelletising or granulating a mouldable clay-like material[67, 68] or shredding soil,[69] de-rinding hog fats,[70] and a metal chip breaker.[71] The beater wheel mill[72] and centrifugal mill[73] are suitable for axial feeding with airborne particles which leave the mills tangentially along with carrier air.[74]

Disc mills

Disc mills are used for intermediate grinding of a variety of materials which cannot be effectively dealt with by other machines. A typical application is the grinding of waste rubber into mesh sizes 20, 30 and 40 at outputs ranging from 150 to 200 lb./hr.[75] A toothed and grooved disc prevents clogging by sticky materials;[76] a similar effect can be attained by coating the grinding area with splinters of tungsten carbide bonded into the steel disc with cobalt.[77] In one mill the grinding disc, rotating about a vertical axis, is kept free-running by a surrounding vibratory ring;[78] in another, a series of spaced cutting discs on one shaft operates between a set of taut shear bars in the spaces between the discs.[79]

Special types of disc mill

A variant of the disc mill is a comminuting machine having a horizontally rotating cutter working against a perforated plate.[80] Other types described in patent literature are multistage discs with separate adjustment at each stage,[81] and a continuously operating bowl-type crusher into which material is fed and after crushing by an eccentrically mounted disc is discharged through the perforated bowl.[82]

Pinned disc mills are specially recommended[83] for the reduction to powder form of medium hard or friable substances such as drugs, roots, synthetics, oxides, etc. The powder produced is usually between the limits of 70% through 200 mesh to 90% through 300 mesh. In one type, the raw material is fed by a worm-type feeder down a feed tube into the chamber containing the disc. There it passes between the stationary and the moving disc receiving repeated impacts from the circular rows of pins. The various parts of the mill, such as feed worm, hopper, cover plate, pinned discs, dust bags and discharge chute, may all be separately removed for cleaning or renewal. A magnetic pulley may be fitted to remove tramp iron.

Cone crushers

Developments in cone crushers appear to be confined to small but important design improvements relating to the mounting of the external motor,[84] use of V-belts for driving the eccentric sleeve[85] and general layout.[86]

Roll crushers

Roll crushers are used for the heaviest duties and also for light, specialist size-reduction operations. Not often, however, is it claimed that one machine will take simultaneously both large and small pieces of material.[87, 88] The apparently impossible is achieved by the use of square-cut grooved rolls, presenting at the same time valleys and high spots, the latter being in face-to-face relationship.

For crushing stone, a roll crusher[89] is mounted so as to discharge the chippings forcibly against angled deflector

plates which further reduce the splinters and secure good mixing. Another crusher, used mainly for grain, operates with a cascade plate to deliver the material into the nip between the rolls, which run at slightly different speeds to obtain a tearing action besides a straight crushing effect.[90]

Other developments include a roller guide with adjustment screw,[91] hydraulic roller pressure control,[92] a novel safety guard,[93] an automatic roller adjustment operating from a sensing element in the feed[94] and a multi-roll crusher with speed adjustment.[95, 96]

Sugar cane crushing

For crushing sugar cane, the roll crusher still remains supreme and hydraulic mechanisation appears to be leading to more precise control of the mills.[97, 98, 99]

Ring roller mills

There are several types of ring and roller mill, but all basically consist of rollers constrained to roll over a guide ring track. Crushing is largely by pressure. As with other crushing machines, the main line of development is towards greater control of the moving parts.[100, 101] Adjustment for wear is again tending towards the greater use of hydraulic control.[102–105] The compensation for or prevention of wear is naturally complicated by the complex systems of rotation of the rollers and has received a good deal of attention.[106–108]

[*Courtesy: Prodorite Ltd.*

Fig. 5. Ball mill lined with heavy-duty neoprene lining. Such a mill is suitable for grinding chemicals which have an acidic nature or which evolve acid gases.

[*Courtesy: Henry Simon Ltd.*

Fig. 6. 'Entoleter' impact mill. Capacities range from 200 to 500 lb./hr./h.p. Machines up to 40 h.p. are available giving a maximum throughput of 20,000 lb./hr. The 'Entoleter' will reduce a charge of ½-in. material to micron sizes. Sulphate of ammonia, urea, formaldehyde, sugar and limestone are some of the materials that can be reduced.

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[77]Brit. Pat. 814,157.
[78]Ger. Pat. 1,024,782.
[79]Brit. Pat. 801,477.
[80]U.S. Pat. 2,840,318.
[81]U.S. Pat. 2,864,562.
[82]U.S. Pat. 2,856,133.
[83]*Edgar Allen News*, June 1959, **38** (444), 131-134.
[84]Ger. Pat. 1,027,042.
[85]Ger. Pat. 1,030,145.
[86]U.S. Pat. 2,829,842.
[87]U.S. Pat. 2,879,952.
[88]U.S. Pat. 2,879,950.
[89]U.S. Pat. 2,879,007.
[90]Brit. Pat. 803,841.
[91]Brit. Pat. 811,623.
[92]Brit. Pat. 796,039.
[93]D. J. Mills and G. W. Tice, *Brit. Plastics*, 1958, (7), 308.
[94]Brit. Pat. 804,420.
[95]Australian Pat. 32,585/57.
[96]Australian Pat. 32,586/57.
[97]U.S. Pat. 2,869,452.
[98]Ger. Pat. 1,043,978.
[99]U.S. Pat. 2,832,280.
[100]Brit. Pat, 804,811.
[101]Ger. Pat. 1,028,856.
[102]Brit. Pat. 806,630.
[103]Brit. Pat. 805,813.
[104]Brit. Pat. 807,008.
[105]Brit. Pat. 806,630.
[106]U.S. Pat. 2,848,170.
[107]U.S. Pat. 2,879,006.
[108]U.S. Pat. 2,876,955.

Part 2 of this article will discuss practical studies of ball-mill and tube-mill operation; fine-grinding mills; refuse disintegrators; pelletising; flour grinding; coffee mills; meat mincing and other applications of size-reduction machinery.

Practical Advances in Chemistry

A NUMBER of industrially useful subjects have been investigated by the recently renamed National Chemical Laboratory of the Department of Scientific and Industrial Research, as is revealed in the latest report. Below, work on the extraction and purification of various metals, the microbial production of hydrogen sulphide, and some corrosion problems, is briefly noted.*

Natural leaching of uranium

It has been known for many years that certain pyritic ores can be satisfactorily leached merely by stacking in heaps and watering regularly. The principle involved is briefly that in the presence of air and water the FeS_2 gives rise to H_2SO_4. This process, known as natural leaching, is being studied with a number of different uranium-bearing ores. Tests are being carried out in specially constructed PVC columns having a sump at the base for collecting the effluent and with the ore supported on a perforated plate. Water is added periodically to the top of the column and effluent run off for analysis. Pyrite is added to ores which contain little or no pyrite.

As the major section of any conventional uranium extraction plant is the settling and filtration stages in which the leach liquors are separated from the leached ores, the saving in capital expenditure and operating costs on these stages, apart from the more obvious saving in reagent costs, is of great economic importance.

Solvent extraction of uranium

An interesting possibility which has been studied during the year is that of direct solvent extraction from uranium ore pulps. Conventional extraction processes (*e.g.* ion-exchange) require the undissolved solid, which amounts to between 90 and 95% of the ore, to be separated from the uranium-containing solution by filtration, or countercurrent decantation in thickeners. This liquid/solid separation is expensive because of the large bulk of solid which has to be filtered. Many uranium ores have very poor filtering and settling properties and these ores necessitate large filtration or thickening units.

The uranium present in the leached pulps may be extracted by a limited contact between the phases, and a disc contactor has been designed which makes use of this principle.

The leached pulp and solvent are pumped countercurrently to one another through the disc contactor unit, which consists of a cylindrical vessel in which rotate a number of discs on a centre shaft. The discs are interleaved with stationary separators to reduce short circuiting of the solvent and aqueous phases. The discs are wetted by the aqueous phase and, as they rotate, a film of the aqueous solution is carried through the solvent, so effecting transfer of uranium.

The solvent used is a 0.1 M solution of di(2-ethylhexyl) hydrogen phosphate in kerosene. The loaded solvent is stripped of uranium in the normal manner. The use of long-chain amines as extractants is less satisfactory.

Blocking of the unit with settled solids does not occur provided the ore is finely ground and is fed to the unit as a slurry containing a sufficiently high percentage of solids. This improves the economics of the process by giving a higher solvent loading with consequent decreased strip-reagent consumption.

Preliminary work has been commenced on a multi-stage unit and discs made of *Perspex*, glass and laminated PVC have been tried. It was at first thought that the ion-exchange properties of the latter might facilitate extraction, but results obtained show that this is not an important factor.

Thorium extraction

With a view to producing reactor-grade thorium by a solvent extraction procedure an investigation was commenced into the possibility of selectively stripping impurities from the loaded solvent, *Primene JM-t*. Preliminary experiments with HCl and H_2SO_4, varying in concentration between 0.01 N and 0.1 N, indicated that neither of these reagents was suitable. A much improved result was obtained when sulphurous acid was used.

Aluminium purification

The further purification of superpure grade (99.99%) aluminium by zone melting has been investigated. The preliminary results indicate a reduction of the iron, copper and zinc contents to the order of 1 p.p.m. Rare-earth metals, while detected in the original material, were not found in the refined product. There appears, however, to have been little or no reduction of the silicon and magnesium contents.

Microbial production of sulphide

The United Kingdom is largely dependent on imports for its sulphur supplies, both of elementary sulphur and pyrites. Should these fail, the economy of the country would be seriously affected; hence the use of indigenous materials for sulphur or sulphuric acid production is being explored. One possibility is the application of sulphate-reducing bacteria for the production of hydrogen sulphide, which can be converted to elemental sulphur or sulphuric acid by well-established chemical methods. Technically, the problem presents no insuperable difficulties; its successful industrial application is a question of economics, and in particular the availability of sufficient cheap raw materials. The principal materials required for microbiological sulphate reduction are (*a*) sulphate, of which there are plentiful cheap supplies in the U.K., and (*b*) reducing material 'equivalent' to the amount of sulphate to be reduced; this may be either a suitable organic material or hydrogen gas. A survey of raw materials available for this project showed that sewage sludge was the only suitable reducing material which was cheaply available in sufficient quantities to make an appreciable contribution to our sulphur requirements.

The 50-gal. pilot plant at Beckton (see CHEMICAL & PROCESS ENGINEERING, March 1957, page 112) has been used for investigating various problems preparatory to larger-scale trials, and showed that calcium sulphate wastes from industrial processes were as effective as gypsum, and sulphide sludges settled more easily and permitted the removal of more water than methane sludges. Purification of the final sludges was also investigated.

Corrosion problems solved

The specialised knowledge accumulated by the laboratory's research teams is made freely available and each year a large number of enquiries are received for advice and assistance.

(*Concluded on page* 433)

* 'The Report of the National Chemical Laboratory, 1958,' Department of Scientific and Industrial Research (H.M.S.O., 5s. 6d.)

Electricity in Chemical Works

GENERATION

Back-pressure generating sets

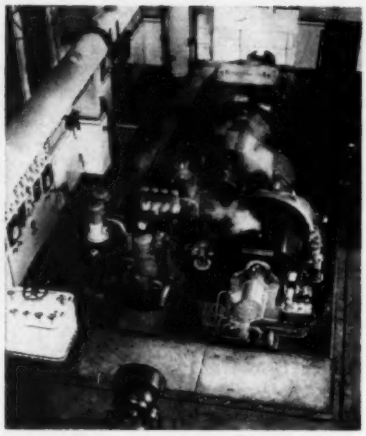
Where low-pressure steam is required for heating and process purposes, the production of steam at a higher initial pressure and its expansion through a turbine have long been established as an economic means of generating electrical power. The use of a back-pressure turbine for this purpose enables maximum economy to be achieved, since all the steam entering the turbine is exhausted to process and no heat energy is lost in condensing plant.

Back-pressure turbines are also used as superposed units on existing turbo-generator plant to improve the overall thermal cycle efficiency. In such an installation the existing low-pressure boilers are replaced by a high-pressure boiler and the steam after passing through the turbine is exhausted to the existing low-pressure turbines at their designed pressure.

Discussing this subject in a booklet on geared steam turbo-generating sets, the English Electric Co. Ltd. point out that the relationship between the quantity of steam exhausted from the turbine and the electrical output is a fundamental characteristic of the back-pressure machine. When the ratio of steam and power demands is not substantially constant the turbine should operate in parallel with an alternative source of power. In this way fluctuations in electrical output caused by variations in process steam demand can be provided from the outside supply. Conversely, excess electrical power generated in meeting the process steam demand can be fed into the external system.

Where a back-pressure turbine is the only source of electric power, arrangements must be made to provide additional steam through a reducing valve when process steam exceeds power demand. Conversely, when power demand exceeds the process steam demand, arrangements to exhaust surplus steam are necessary.

When power and process steam requirements vary independently over a wide range, a pass-out condensing turbine generally provides the most economical solution. In this case varying amounts of process steam can be provided at controlled pressure and fluctuating power demands can be met independently of any external electrical system.



The 4,000-kw. set at the Boots factory showing high- and low-pressure cylinders, common gearbox and alternator.

To meet the steam and power requirements of different manufacturing processes, a range of standard back-pressure turbines is available.

Economy in power generation

As an example of how thoughtful planning and skilful engineering can reduce electricity costs, we may consider a recent change at the Beeston power station of the Boots Pure Drug Co. factory near Nottingham. Here a new, 4,000-kw., twin-cylinder, cross-compound, pass-out, condensing steam turbo-alternator set has been brought into use to replace a 1,000-kw. back-pressure unit which was installed in September 1929. It has been installed in such a way that it occupies the same site as the smaller power unit, so while the number of generating sets at Beeston is still five, capacity is pushed up to 11,750 kw. In addition to this, two back-pressure sets at the Nottingham power station of Boots can each provide 1,500 kw., making a total generating capacity of 14,750 kw.

The new unit comprises a W. H. Allen & Sons high-pressure turbine running at 6,000 r.p.m. and a low-pressure turbine running at 4,000 r.p.m. Both are geared to a B.T.H. alternator which runs at 1,000 r.p.m.

Cost of the additional unit was about £110,000, but Mr. H. L. Palmer, chief engineer of Boots, estimates that importing extra power to meet increasing demands would also have involved a substantial capital outlay in alterations to the distribution system, including the erection of a new sub-station, the total cost of which was estimated at between £40,000 and £50,000.

Moreover the economy of space allowed by the new unit, which occupies less than 1,000 sq. ft., avoided an extension to the Beeston power house of some 2,000 sq. ft. which would otherwise have been required to house a more conventional direct-in-line set and which would have added at least £20,000 to the cost of this installation.

HEATING

Electric surface heating for hazardous areas

Electric surface heating offers considerable advantages in many industrial processes. Where inflammable materials are involved, suitably protected heaters of this type provide one of the few safe methods of applying controlled heat.

As the name implies, surface heaters are made to follow closely the contours of the vessel to be heated. The surface of the heating unit in contact with the vessel is therefore made of glass or quartz fibre cloth, which has the required flexibility to ensure contact over the entire area. This cloth is backed by the actual heater, comprising a heating element which is in itself flexible and is mounted on a resilient web of glass cloth. Heat is generated in nickel alloy resistance wire which is electrically insulated against an outer protective stainless-steel sheath by means of a mineral material. To prevent heat losses, several inches of high-grade insulation are then provided, the entire assembly being supported by a rigid outer casing of fabricated sheet metal. The glands and terminal boxes in which the heating element terminates are of the certified flameproof type and are mounted on the casing, which also provides the required protection against mechanical damage.

The heating element of smaller units normally forms a single electrical circuit, while in larger heaters the total input is usually divided over a number of sub-circuits. In either case, current is supplied to the heating element through flameproof glands and terminal boxes. All joints in this construction are specifically designed to prevent any internal explosion from

Chemical works make considerable use of electricity for lighting, process heating, motive power, electrolysis plants, furnaces, electrostatic precipitators, instrumentation and automatic control, and in numerous other ways. Correct choice and installation of electrical equipment provides great scope for economising in capital expenditure and operating costs. It is not the purpose of the accompanying review to deal with all types of electrical equipment, some of which are complete subjects in themselves, but to highlight some recent developments which may serve as a guide to the advances that have been made.

being propagated through the joint gap to ignite gases in Groups I, II and III.

Approval of electric surface heaters under the provisions of Electricity Regulation 27 is made subject to one very important qualification: at no time during its operation in a hazardous area must the temperature of the heating element be allowed to exceed the ignition temperature of the inflammable gas which renders the area in question hazardous.

A number of standard electric surface heaters are produced by Isopad Ltd., ranging from small mantles for use in laboratories, for flasks with capacities from 2 to 20 litres, to jackets for cylindrical vessels, and from drum heaters to heating boxes for valves, instruments and meters. These are all available fitted with outer sheet-metal cases and flameproof fittings. The only exceptions are the flexible electric heating tapes, used for tracing along or spiralling round pipework, on which the heating element terminates in $\frac{3}{4}$-in. flameproof glands. A similar method is adopted where the heating unit is required simply as a panel, without lagging and outer sheet-metal casing.

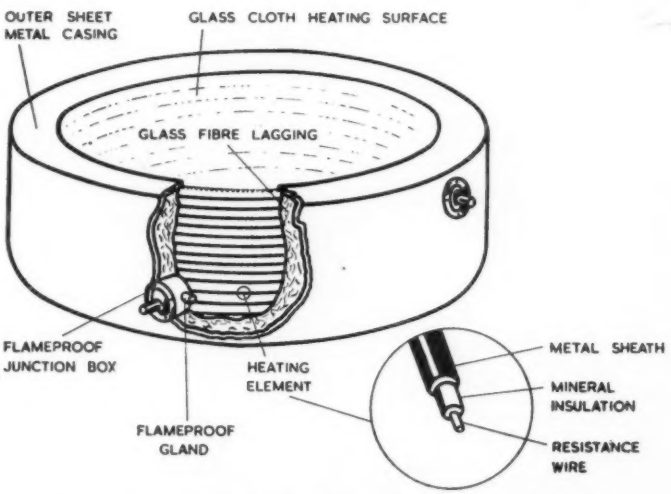


Diagram showing details of 'Isopad' electric surface heater.

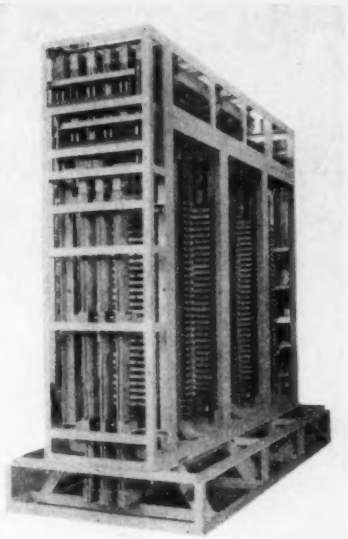
RECTIFICATION

Germanium rectifiers

For the conversion of a.c. to d.c. for use in electrochemical processes, a notable development in recent years has been the use of germanium diodes in rectifiers, which makes it possible to operate with a small number of high-current cells, and to obtain high efficiencies at low initial and operating cost.

Various types of germanium rectifier are on the market and overall efficiencies of between 92 and 98% have been cited for d.c. voltages of up to 300 in some cases and up to 500 in others. However, one manufacturer of germanium rectifiers considers that the most effective field for germanium is in the range 8 to 150 v., where the low forward drop of germanium can be used to the maximum advantage.

One interesting germanium rectifier installation is that used for the electrolysis of brine to produce chlorine, at the works of the Glamorgan Acid & Alkali Co. This 23,000-amp. installation has an ultimate capacity of 3 Mw. The rectifier, supplied by Westinghouse Brake & Signal Co., is water-cooled, the cooling circuit being



The compact design of the Westinghouse silicon rectifier is illustrated by this 14,000-amp., 120-v. cubicle which occupies a floor space of 4 ft. 6 in. × 12 ft. 8 in.

electrically insulated from the d.c. circuit, thereby eliminating the problems which might otherwise arise as a result of leakage currents arising from low insulation resistance.

A somewhat larger germanium rectifier installation is that used at the Ellesmere Port electrolytic chlorine plant of the Associated Ethyl Co. Ltd. The rectifying plant, supplied by the British Thomson-Houston Co. Ltd., is rated at 18,400 kw., 80,000 amp., 230 v. and the rectifiers are connected in a three-phase bridge circuit with phase-shift transformers to give 48-phase overall operation. There are two sets of rectifier equipment each of four units and both sets are controlled from a central control room.

Silicon rectifiers

Rectifiers using silicon cells are also available and, while they do not attain quite the same efficiency as does germanium in the low-voltage range, they stand up better to high ambient temperatures. Their attraction for warmer climates is illustrated by two recent installations, one for the electrolytic production of chlorine and caustic soda in India, and the other for the production of manganese in the Transvaal. The rectifier equipment for the Indian chlorine plant was manufactured in Britain by Westinghouse and is rated at 27,500 amp. at 60 to 120 volts d.c. It comprises a regulator and transformer connected to the 22-kv. system, a water-cooled silicon rectifier, and a

control cubicle with automatic adjustment of the d.c. current—so that the rate of production of chlorine is maintained constant. The rectifier equipment for the South African manganese plant, giving 2.6 Mw., was supplied by Standard Telephones & Cables Ltd. and was briefly described in CHEMICAL & PROCESS ENGINEERING, August, page 290.

Selenium rectifiers

Selenium rectifiers are capable of operating in a wide range of temperature, *e.g.* from +55°C. to –40°C. or lower. Hackbridge & Hewittic, who offer oil-immersed selenium equipment, point out that the use of oil-immersed rectifier equipment is often regarded in a similar light to oil-immersed transformers but, in fact, whereas with transformers, natural air cooling becomes uneconomic for units above a certain capacity and it is cheaper to oil-immerse, in the case of selenium rectifiers, air cooling, whether natural or forced, is more economic than oil for all ratings.

The losses to be dissipated are several times greater than for a transformer of equivalent capacity, also the permissible oil temperature is lower. With the oil-immersed equipment, therefore, as the capacity increases the provision of sufficient cooling surface on the tank has to be met by the use of a considerable number of cooling tubes, and when these become inadequate the rectifier units have to be divided between a number of tanks.

The transfer of heat to the ambient air takes place in two stages—firstly from the rectifier units to the oil and secondly from the surface of the tank to the air. In the case of air cooling, however, the heat transfer takes place directly from the rectifier units to the circulating ambient air within the assembly and no surrounding heat-transfer surface is required. Thus the oil-immersed arrangement occupies more space.

STARTERS AND CONTROL EQUIPMENT

Along with the demand for reliable, medium - size, squirrel - cage motors goes one for automatic control devices in keeping with modern process requirements. The electrical equipment manufacturers' awareness of this demand is shown by the considerable variety of available controls.

Typifying present trends in automatic control is an automatic flameproof gate-end panel for the control of squirrel-cage motors at 400 to 650 v. with full-load currents up to 80 amp. The panel, designed by the General Electric Co. Ltd., carries the Ministry of Fuel and Power Certificate for Group 1. The control circuit is intrinsically safe and earth-leakage protection is provided. A reversing isolator and local control switch are mounted on the unit. For remote operation, a flameproof remote control switch is connected to the panel through the pilot and earth cores in the trailing cable to the motor.

In many applications squirrel-cage motors cannot be switched direct on the line, either because the supply available is inadequate for the starting current or because the high starting torque is unsuitable for the machine being driven. In these cases various methods of reduced voltage starting are at present employed, including the ' primary resistance ' method in which the motor is connected to the line through fixed metallic resistances which are short-circuited after an accelerating period. This method enables the starting torque to be adjusted to the required value but results in a high current peak at short-circuiting unless the resistance is eliminated in several steps, which is uneconomic.

It is claimed that this disadvantage is overcome in a French invention, the *Statormatic* starter, manufactured by Lee Guinness Ltd. of Northern Ireland. This is of the ' primary resistance ' type but employs thermo-variable liquid resistances in place of fixed metallic resistances.

This system is claimed to yield the following advantages:

(*a*) Automatic variation of the resistance in relation to the starting current of the motor and automatic short-circuiting undertime control at the end of the starting cycle.

(*b*) Current and torque peaks are reduced during starting.

(*c*) Smooth acceleration of the motor reduces the mechanical stresses on the machine being driven.

(*d*) The variation in the resistances produces a progressive increase of the torque of the motor during starting in relation to the resistance torque of the equipment being driven.

For the direct switching of squirrel-cage motors up to 7½ h.p., a new automatic starter called the *Dupar* TFK has recently appeared, incorporating a neon running indicator lamp, single phasing and overload protection for the motor windings and silver contacts.

Designed for heavy-duty operation, its deep-drawn steel case can be wall or pillar mounted either singly or in tandem. The whole internal operating unit can be obtained independently of the case for mounting in a separate enclosure.

The makers of this unit, Dewhurst & Partner Ltd., also offer a second model, the TFW, a reversing starter using the same standard components.

MOTORS

Electric motors are indispensable to most chemical works today, providing as they do the drive for pumps, crushing and grinding machinery, mixers, conveyors and many other types of equipment the sudden cessation of which might mean a considerable loss in production. A wide variety of reliable motors is available to meet continuous-loading conditions and in choosing one of these for a particular duty considerable care should be taken to see that it is the right type and size, that the cooling and variable-speed arrangements are suited to that particular job, and that all related factors are taken into account so as to achieve the maximum ratio of efficiency to installation and operating costs. This is in addition to ensuring that the design of the motor meets the flameproof, weatherproof or corrosion-resistant requirements of the particular location.

Fan-cooled squirrel-cage motors

One range of weatherproof motors of the above description takes account of the fact that most flameproof motors in the medium range of horsepowers at the higher speeds are direct-coupled to centrifugal pumps. In this particular design roller bearings are no longer used on standard machines for direct-coupled drives: this eliminates the problems of ' stationary ' vibration. The standard machines are equipped with a ' metric size ' ball-bearing at each end. Location of the rotor is achieved through the rigid mounting of the bearing at the driving end; the bearing assembly at the non-driving end includes a spring loading device which permits axial movement due to shaft expansion. An alternative ball and roller bearing arrangement is available for pulley drives.

In the arrangements for cable entry, particular attention is paid to the spacing of the terminals. The terminal box is made in one piece and, to ensure a weatherproof joint, a neoprene gasket

is used between the lid and the splitting face on the box. A spigot provides the flameproof joint.

A further feature of these motors, made by Metropolitan-Vickers, is the pressure relief valve, which has a large aperture for excess grease rejection into a collecting tray.

Vibrating drives

An electric motor specially designed for vibrating drives is being produced jointly by the English Electric Co. and the Grantham Electrical Engineering Co. In this completely self-contained unit all the mechanical parts associated with an eccentric shaft arrangement are eliminated. Vibration is generated by out-of-balance weights at either end of the motor which can easily be adjusted by single bolts to give the required output.

Because of its vibrating motion, the motor must be mounted on a resilient base. Operating at 1,500 r.p.m. synchronous speed, it has a power output of up to 7,500 lb. centrifugal force, or 10,000 lb. at 3,000 r.p.m. The motor is operated from a three-phase 50-cycle supply at 110 to 650 v. Greater outputs and other supply frequencies can be provided for.

Drive for a Banbury mixer

An example of the special requirements which electric motors often have to meet can be seen in the driving arrangements for a Banbury mixer used for mixing and compounding rubber stock at the Wolverhampton works of the Goodyear Tyre & Rubber Co. This mixer consists of two rotors on which cams are formed to make an interrupted spiral. A slight speed difference is provided between the two rotors to ensure constant intermixing.

An English Electric, 1,500-h.p., 743-r.p.m., 6,600-v. slipring induction motor, providing high starting and accelerating torques, drives the Banbury mixer. Because of the presence of carbon black in the atmosphere, special precautions had to be taken in the design of this machine. Carbon black is noted for the extreme fineness of its particles and its presence on the windings, sliprings or brush gear is undesirable. This problem is overcome by adopting a closed-air-circuit arrangement, with a single water/air cooler mounted at the side of the machine. The sliprings are outside the cooling air circuit and are totally enclosed. All machined joint surfaces are fitted with seals, and shaft seals are provided on the pedestal sleeve bearings.

Counting the Cost of Electricity

At a recent London symposium, organised by the Graduates and Students Section of the Institution of Chemical Engineers, Mr. R. S. Bickle (National Coal Board) gave a paper in which he summed up the factors involved in estimating the cost of services such as steam, water, electricity, gas, etc., in a chemical factory. The following extracts deal with electricity costs.

A SUITABLE basis for estimating the cost of electricity is 1½d. per unit. In Britain there are 12 Area Electricity Boards, which all have different industrial tariffs. These tariffs are based on: (*a*) demand charge or rental for capacity and (*b*) cost of providing and transmitting the electricity. The demand charge varies with the load factor. A factory operating a single shift for five days a week, and allowing for tea breaks, only has a load factor of 17%. Continuously operating chemical works have some of the best load factors. Lower rates are charged for two- and three-shift working. Special rates are given for very high loads, such as for aluminium refining, or for the use of furnaces in 'off-peak' hours only.

The average cost of electricity to industrial users in 1958-59 varied from 1.134d. to 1.330d./unit for those areas which include coal fields in them, and from 1.426d. to 1.898d./unit for the non-coal-producing areas.

Guide to tariffs

The following may serve as a first guide to the industrial tariffs for high-voltage supplies:

(*a*) *Maximum demand below* 200 *kva.:*

Standing charges, £6 16s. to £8 12s. per installed kva.

Consumption less than 150 kw./month/installed kva.—about 0.8d./unit.

Consumption greater than 360 kw./month/installed kva.—about 0.6d./unit.

These charges alter by stages to reach:

(*b*) *Maximum demand over* 3,000 *kva.* (Note, five Area Boards do not differentiate above demand of 1,000 kva.):

Standing charges, £5 10s. to £7 10s.

Consumption less than 150 kw./month/installed kva.—0.55 to 0.8d./unit.

Consumption greater than 360 kw./month/installed kva.—0.46 to 0.52d./unit.

There is, as well, a fuel cost variation addition to cover all changes in the costs of fuel, transport, wages, etc. This addition or reduction is 0.00059d./unit for each penny by which the fuel costs per ton in the year shall be above or below 60s. At present this addition amounts to nearly 0.2d./unit.

Finally, there is an additional penalty for those accounts charged in kilowatts, if the power factor falls below 0.9 or 0.85; this usually amounts to a few per cent. Of course, if the supply is charged on kva. used, such a penalty is not necessary.

Boilers and electricity generation

A 1½-million-lb./hr. boiler at 2,400 p.s.i. and 1,050°F. costs £1½ million, excluding chimney and dust precipitators. This boiler with a 200-Mw. generator, costing £1¾ million, should generate electricity at 0.3d./unit, the steam being reheated to 1,000°F., with an efficiency greater than 35%. Such a boiler takes two years to erect on site.

A 50,000-lb./hr. boiler at 400 to 600 p.s.i. can operate a 5-Mw. generator and this, complete with condenser, feed heaters, etc., would cost £105,000.

Dr. E. T. Moss, in another paper, gave some cost figures for back-pressure turbines. These were:

kw.		£/*kw.*
5,000	..	12.5
10,000 to 15,000	..	10.3

Electric installations

The cost of the electric installation in a factory with 1,000 to 5,000 installed h.p., the lighting, included as h.p., being 2 to 4% of the total, is between £30 and £40 per installed h.p. This is starting with a 3.3-kv. supply, and providing transformers for 450 to 500 v. and 220 to 240 v., switchgear, sub-stations and wiring. This estimate assumes a few large motors of 300 to 400 h.p. operating directly on the 3.3-kv. supply, and the rest of the motors graded in sizes down to fractional-h.p. motors. The cost should be increased if much spare transformer capacity is installed, or if there are many small motors or much flameproofing.

If in the above example the transformers are excluded, the cost comes down to £7 to £13 per installed h.p. If the size of the installation is reduced to, say 200 to 300 h.p., the cost can easily rise to £30/h.p., without the cost of the transformers.

NUCLEAR NOTES

Nickel-alloy evaporator

Something new in evaporator design and construction has come forth to solve tricky problems in concentrating radioactive wastes which Consolidated Edison Co. of New York Inc. must dispose of after its new 275,000-kw. Indian Point nuclear power plant on the Hudson goes into service in April 1961. Designed by Chicago Bridge & Iron Co., the evaporator will be made entirely of *Inconel* nickel alloy and will have an entrainment section of woven stainless steel six times the usual thickness. The design calls for a welded flangeless unit.

According to the designers, the unit will accept wash-down and purge water from the entire plant (reactor area, laboratory, laundry and filter backwash operations) and vaporise it so effectively that less than five parts in 100 million of dissolved solids are in the discharge. An ion-exchange unit will cut this amount to less than one part in 100 million.

The concentrate of radioactive wastes—up to 30% dissolved solids—will be disposed of according to procedures of the Atomic Energy Commission and New York State.

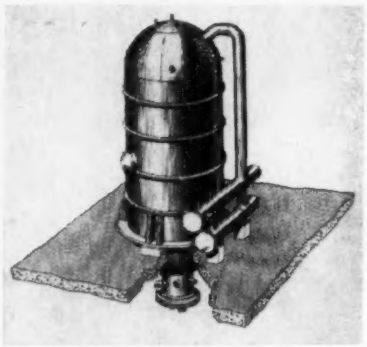
The evaporator is engineered for a 6,000-lb./hr. boil-off, measures only 19 ft. in height by 6½ ft. in diam., and has hairpin steam-heating loops which may be cleaned by thermal shock. The mesh demister (entrainment separator) will be 3 ft. thick and every vessel weld will be completely inspected radiographically.

Built to A.S.M.E. code for handling lethal fluids, the unit has been rated by Consolidated Edison as a primary vessel because the evaporator will handle water which has been used in the primary loop of the reactor steam generating plant. The unit concentrates all material requiring evaporation that leaves the plant.

European atom smasher

The European Organisation for Nuclear Research (C.E.R.N.) recently announced that its big proton synchrotron had reached its designed energy, producing a beam of protons of an energy of 24,000 Mev., for the first time. This is the culmination of six years' work of design and construction at the C.E.R.N. laboratories at Geneva.

The machine, measuring 200 m. across and the most powerful in the world, has thus justified its designers and the faith of the 12 nations of Western Europe who came together six years ago to form C.E.R.N. Western Europe now has at its disposal a unique tool of research for the exploration of the inner structure of the atom.



Artist's impression of all-'Inconel' evaporator for concentrating radioactive wastes generated at the Indian Point (U.S.A.) atomic power plant.

Neutron-source reactor

The United Kingdom Atomic Energy Authority have signed a contract with the Hawker Siddeley Nuclear Power Co. for the purchase of a reactor to be installed at the Atomic Energy Establishment, Winfrith, Dorset, to be in operation by December 1960. Contracts for shielding and other equipment associated with the reactor are being placed.

The reactor, which will be known as *Nestor* (neutron source thermal reactor) is based on the company's *Jason* reactor. Its purpose will be to provide the neutrons required for the experimental assemblies of nuclear fuels and moderators which are used to obtain data for the design of future reactor systems. To meet the requirements of the Authority the *Jason* reactor has been modified to be capable of continuous operation at a power of up to 10 kw. and its layout has been altered so that it can drive up to five experimental assemblies simultaneously. Details of the modifications have been worked out in collaboration between the Authority and the company.

The nuclear fuel in *Nestor* is an alloy of highly enriched uranium and aluminium arranged in an annulus of plates. Natural water is used both as coolant and moderator. The reactor is capable of operation of 10 kw., giving a thermal neutron flux of 10^{11} neutrons/sq.cm./sec. in the centre of the core and of up to 10^{8} neutrons/sq.cm./sec. in typical assemblies. The thermal neutron flux can be varied by altering the reactor power level, by using neutron shutters or by rearranging the fuel loading in the annular core.

Research reactor for Italy

A privately owned and operated nuclear research reactor, designed and constructed by the A.M.F. Atomics Division of American Machine & Foundry Co., has started operations at Saluggia, Italy, about 20 miles north-east of Turin. It is operated by an organisation known as *Sorin* (Societa Ricerche Impianti Nucleari) which is jointly owned by the prominent European industrial groups of the Fiat Corporation of Turin and the Montecatini Corporation of Milan. A pool-type reactor, it has an initial thermal output of 1 Mw. and a potential capacity for future operation of 5 Mw.

The reactor was fuelled with 3,238 g. of Uranium 235 provided by the United States Atomic Energy Commission.

Rapid testing for radioactivity

A leading member of the Electronics Division of the United Kingdom Atomic Energy Research Establishment, Harwell, has invented a device which permits very quick testing for weak radioactive contamination, such as might be found on the hands of personnel working with radioactive materials.

The invention is based on the observation that, although the random nature of individual radioactive disintegrations requires that very many be counted if a statistically reliable measurement of radioactivity is needed, in cases where it is only required to find out whether or not the activity exceeds a set level, it is—in principle—only necessary to carry out a long count when the activity is close to this level.

Sources which are much stronger or much weaker can—in principle—be disposed of by making a far less accurate measurement in a much shorter time.

This can be achieved by applying the principle of sequential sampling, a technique used in production control. The method is to count the number of radioactive disintegrations observed since the beginning of the counting period and to subtract continuously the number which would have been observed had the activity been exactly equal to the set level.

The difference between these two numbers grows continuously and when it has attained a predetermined value (positive or negative) the test is ended. The sign of the difference then shows whether the activity is greater or less than the set level. The more the activity differs from the set level the faster this difference is accumulated and the shorter is the time taken to complete the test.

The electronic device which performs this function is called a difference integrator. It may take several forms. In one, each pulse due to a disintegration causes the charge on a capacitor to be increased by a known amount. At the same time, charge is being continuously withdrawn from the capacitor at a rate corresponding to the set level of activity. When the net charge on the capacitor reaches a predetermined positive or negative value a 'high' or 'low' indicator operates and the test is ended. Another version uses a reversible pulse-counting device driven in one direction by the unknown pulses and in the other by pulses from a standard pulse source.

The method has been studied experimentally and on a digital computer. It is found that, although a few sources whose activity is very close to the set level may cause very long counting periods, there are several simple ways in which these may be curtailed without appreciably affecting accuracy.

The advantage to be obtained by use of the above method, rather than conventional methods, depends on the expected distribution of activities between samples and on the accuracy required. In the case of routine monitoring of activity on the hands, a five-fold reduction in average counting time is obtained without loss of accuracy. In another case, the mean time for the routine measurement of a weak radioactive sample is reduced from 8 hr. to 20 min., again without loss of accuracy.

Radiation-shielding window

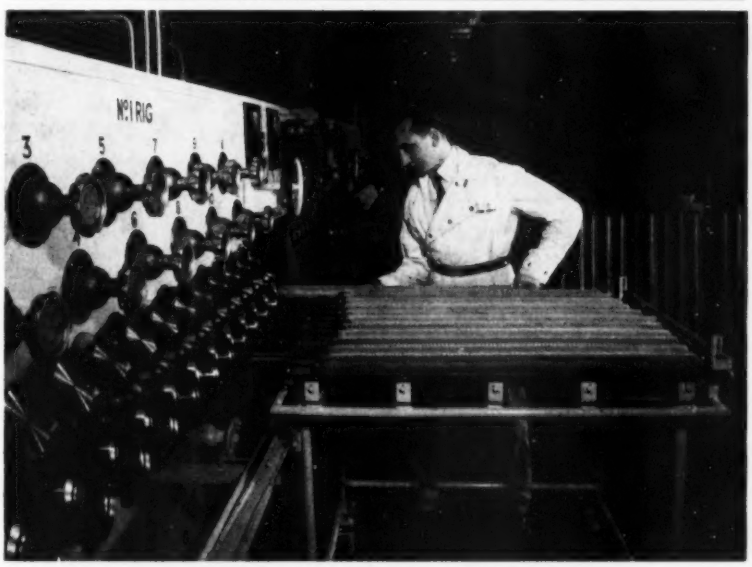
A solid-glass radiation-shielding window, to be exhibited in Britain shortly, permits observations on radioactive materials in laboratory work. The overall dimensions of the 'hot' face of the window are 40 in. × 28 in., and the thickness is 29¾ in. Total weight is 3,200 lb. On receipt of radiation from a Cobalt 60 source the protection offered by this window is equivalent to that given by 48-in. thickness of normal concrete or 9½ in. of lead.

The window, produced by Chance-Pilkington, consists basically of five blocks of 4.3 g./c.c. density, the two 'hot'-side blocks being stabilised to reduce the tendency to darkening upon receipt of large doses of radiation. Spaces between the glass blocks are oil-filled to reduce visible transmission losses.

Plutonium fuel tests

Flow tests on the first fuel element fabricated for use in the plutonium recycle test reactor have begun at the Hanford (U.S.A.) atomic energy plant. The plutonium recycle project is a long-range experimental programme and is expected to lead to the use of plutonium as a fuel for nuclear reactors. Development of the plutonium recycle concept is being undertaken at Hanford laboratories, which U.S. General Electric operates as prime contractor for the U.S. Atomic Energy Commission.

Primary function of the flow tests is to determine the effect of the fuel element shape on the overall characteristics of the flow of the reactor cooling water. These tests will also provide valuable information on the ability of the fuel element to stand up to reactor operating conditions.



TESTING URANIUM FUEL RODS

Over a million uranium fuel rods have now been produced at the Springfields Works of the U.K.A.E.A. The photograph shows these rods being leak-tested. Metropolitan-Vickers mass spectrometers are widely used for this work.

Practical Advances in Chemistry

(*Concluded from page* 427)

The largest number of enquiries concern the corrosion of metals and techniques for the purification of organic compounds.

Thus, a D.S.I.R. station required an inhibitor for the protection of various metals in an experimental refrigeration system consisting of a 50-50 solution of methanol and water. Protection of another closed-circuit system containing water was sought by a firm constructing an experimental pool-type reactor. In both cases it was suggested that a solution of 2,000 to 5,000 p.p.m. sodium chromate should serve the purpose.

The corrosion of soldered joints in a stainless-steel vessel by sodium nitrite was a problem encountered by an oil manufacturer; sodium benzoate was recommended.

There were two enquiries about sulphuric acid dewpoint corrosion, one of them concerning the rapid failure of a fan operating at 140°C. in the flue-way of a brick kiln. Ameliorative measures were suggested, but it appears that there are still very few coating materials offering protection against prolonged exposure to condensing sulphuric acid.

New Books

Science, industry and economy

This book* contains suggestions for policy and action by industry and Government which may assist in the fruitful application of science.

The authors consider that British industry should first of all think of what it can do for itself, and not expect all its troubles to be eased by the balm of Government action. The first part of the book contains suggestions for management, in small firms as well as in large, on such matters as the communication of scientific knowledge, the use and conduct of research and development, and the finance of innovation. In the second part, the authors examine some of the ways in which Government can make it easier, for instance, by support of research, and by appropriate policies for education, taxation, credit, foreign trade and the control of restrictive practices.

This is the third of a series of reports written for the Science and Industry Committee, which was set up by the British Association for the Advancement of Science, the Royal Society of Arts, and the Nuffield Foundation. The authors are respectively chairman and secretary of the committee and hold chairs in the University of Manchester.

**Science in Industry, Policy for Progress*, by C. F. Carter and B. R. Williams. Oxford University Press, 1959. Pp. 186, 21s.

Atomic progress in the Communist countries

Three distinct kinds of development in the nuclear field can be seen in the Communist countries: (1) in the U.S.S.R., the spread of nuclear techniques from military to industrial fields; (2) in the satellite countries of Eastern Europe, the launching of atomic programmes in areas that are fairly well developed economically; (3) in China, the drive for nuclear expansion in a country backward in science and technology.

The easing of Soviet restrictions on the release of information about nuclear research and the non-military applications of atomic energy has made it possible to produce this useful summary,* which embraces not only the U.S.S.R. but also China, Poland, Czechoslovakia, Rumania, Hungary, Bulgaria, Albania and East Germany.

By using mainly Soviet and Soviet-bloc sources of information, supplemented by some reference to the opinions of Western observers on the Communist countries' atomic work, the author has built up an interesting picture, more remarkable for the care with which it has been compiled than for any sensational revelations.

**Atomic Energy in the Communist Bloc*, by G. A. Modelski. Melbourne University Press, 1959. Available from Cambridge University Press, London. Pp. 226, 30s.

Chemical nomenclature

Nomenclature is the tool by which chemists describe their compounds to one another. Like other tools it can be used in several ways and it can be misused. With this point of view this book* was written, not as a complete textbook but as a guide to chemists to the principles of modern systematic nomenclature. Inorganic and organic chemistry have been treated differently, the former much more fully, though in less space. The discussion of the main differences between British and American practice should be useful to those who read American textbooks and chemical abstracts.

**An Introduction to Chemical Nomenclature*, by R. S. Cahn. Butterworths Scientific Publications, London, 1959. 10s. 6d.

Brine electrolysis

The third in a series of textbooks sponsored by Imperial Chemical Industries Ltd. to help bridge the gap between the chemistry learnt at school and the chemistry as applied in industrial practice, this* gives detailed accounts of the fundamental aspects of brine and salt electrolysis, raw materials and energy requirements, the manufacturing process, packing, storage and transport of the products, production statistics and trends, physical and chemical properties of the products, principle uses of the products and an outline of the historical developments.

There are two appendices, one dealing with the chronology of developments and the other a glossary of technical terms with definitions of units.

**Electrolytic Manufacture of Chemicals from Salt*, by D. W. F. Hardie. Oxford University Press, London, 1959. Pp. 74, illus., 7s. 6d.

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Technology Notebook

Fellowships

The Ciba Fellowship Trust, which was founded for the purpose of furthering the exchange of ideas between scientists in the U.K. and on the Continent, announces that several Fellowships will be awarded for tenure during the academic year 1960-61 at Continental universities or institutions for research in chemistry, physics or some other allied scientific subject. They will be awarded to graduates of universities situated in the U.K. or in the Republic of Ireland, or to members of those universities graduating this year. It is anticipated that some Fellowships will be awarded to recent graduates and others to candidates who have taken their PH.D., or who have already spent some time in industry.

Further details are available from the secretary of the trust, Ciba (A.R.L.) Ltd., Duxford, Cambridge.

Vacuum

A Joint British Committee for Vacuum Science and Technology has been formed. Its objects are:

(*a*) To co-ordinate and help to initiate meetings in the whole field of vacuum science and technology arranged by constituent bodies and

(*b*) to act in the collective interest of the constituent bodies by maintaining liaison with the International Organization for Vacuum Science and Technology and with national vacuum societies and otherwise.

The Institute of Physics has agreed to provide the secretariat for the joint committee; communications should be addressed to the secretary of the committee at 47 Belgrave Square, London, S.W.1.

Welding

Courses on a wide variety of welding topics are organised at the School of Welding Technology. Prospectuses of courses till March 1960 are available from 54 Princes Gate, London, S.W.7.

WHAT'S NEW

Plant • Equipment • Materials • Processes

CPE reference numbers are appended to all items appearing in these pages to make it easy for readers to obtain quickly, and free of charge, full details of any equipment, machinery, materials, processes, etc., in which they are interested. Simply fill in the top postcard attached, giving the appropriate reference number(s), and post it.

Accurate flow and level measurement

Flow and liquid level measuring equipment is available in which *Viton* is used as coatings for diaphragms separating high- and low-pressure chambers in differential converter transmitters. It is claimed that better long-term stability and high stability under varying temperatures may be achieved.

Viton shows good resistance to the action of some chemicals such as alkalis, amines, hydrocarbons and dilute or concentrated mineral acids, according to the manufacturers of the equipment, Honeywell Controls Ltd. **CPE 1405**

Glass comes up trumps in sulphuric acid cooling

Serpentine coolers of borosilicate glass for sulphuric acid cooling have been introduced by Q.V.F. Ltd. These are claimed to provide resistance to attack by sulphuric acid in all concentrations and at all temperatures under oxidising or reducing conditions. Resistance to mixtures of sulphuric acid with oxides of nitrogen is also claimed.

The provision of satisfactory pipe joints in glass acid coolers, particularly those of the serpentine type, has previously offered some difficulties, due mainly to the effects of differential thermal expansion and the high density of the acid. In the new range of sulphuric acid cooling plant Q.V.F. have overcome this problem by using a new type of coupling, invented and developed by Scottish Agricultural Industries Ltd. It consists of a moulded rubber sleeve designed to fit over the tapered buttress ends of glass pipe sections and bends. The sleeve is backed by a stainless-steel gaiter having lugs formed on its edges, some facing outwards and some inwards. The gaiter is secured by two worm-drive clips which are prevented from moving down the taper by the outward-turned lugs, and the rubber sleeve is retained under the gaiter by the inward-facing lugs. The bore of the sleeve has an insert of a special material resistant to the chemical and temperature conditions involved, which forms a seal around the periphery of the pipe ends.

Main advantages in glass acid cooler design and construction offered by the joint include flexibility, avoidance of mechanical stress on the glass buttress ends and complete freedom from leakage. The new joint is more compact than the standard flange and allows closer pitching of cooler tubes with consequent improvement in water distribution and thermal performance. **CPE 1390**

High-temperature tunnel kilns

An extension to their range of small, special - purpose, high - temperature tunnel kilns for the electronics, ceramics and other industries has been introduced by the Allied Engineering Division of Ferro Enamels Ltd.

New coupling for sulphuric acid cooling plant.

These kilns, which are electrically fired, are available in a range of sizes from 15 to 60 ft. and in all temperature ranges from 800 to 1,400°C., and are of the sliding-plate tunnel type.

The new kilns are heated by elements placed under and over the charge, and are particularly suitable for charges of low setting height where stacking is to be avoided. **CPE 1391**

Plastic funnels

Polythene Buchner funnels now offered by Goodburn Plastics Ltd. are claimed to show none of the mechanical disadvantages (*e.g.* cracking due to thermal shock) previously experienced with porcelain funnels.

The new funnels consists of two parts: the filter disc fits snugly into the lower part (funnel) and they can thus be separated quite easily for cleaning purposes. They are available in three sizes.

They cannot be employed with organic solvents nor with water at temperatures exceeding 80°C. **CPE 1392**

Fans for fumes

Paddle-bladed fans, which were specially designed for handling large and continuous quantities of the heavier dusts frequently encountered in the plastics industry, have recently become available. It is claimed that these units can equally well be used for the rapid dispersal of fumes and for most types of ventilation. Both models are fitted with universal fan casings which enable the outlet discharge to be set in any one of eight different positions. The units are also treated with resistant coatings to withstand most corrosive conditions.

The standard model has a 10-in.-diam. impeller, displacing up to 800

cu.ft./min. free air and up to 5 in. water gauge. The heavy-duty model has a 13-in.-diam. impeller, displacing up to 1,800 cu.ft./min. and up to 8 in. water gauge. Makers: Bellanger Bros. Ltd. **CPE 1393**

Hydraulic motor goes slow

Chamberlain Industries Ltd. announce a new slow-speed hydraulic motor, the *Staffa* Mark V. The crank case and cylinders of the motor form a monobloc casting, with seven cylinders arranged radially and each fitted with a detachable head.

At normal pressure of 2,000 p.s.i., the manufacturers state, the maximum output torque is 6,650 lb.ft. with an overall efficiency rating of 94.2%. The speed range is 0 to 75 r.p.m. and the driving shaft may be safely loaded to 6 tons overhang weight. For starting and peak loading, the pressure can be increased to 3,000 p.s.i., giving an increased output of 10,000 lb.ft. **CPE 1394**

Make your own pipe

A continuous process for the manufacture of large-diameter pipe is offered by a German company, who think that the process provides many pipe users with a means of manufacturing their own pipe. It is claimed that the capital investment is kept to a minimum, as well as the conversion cost per ton of steel.

Two machines are available, one giving pipe of 6 to 24 in. outside diameter and the larger from 20 to 58 in. or larger. The entire machine, including welding and strip feed, is operated from one control console. All settings can be checked from this console by means of indicators and dials. Operation is stopped and started by a single button starter and is completely automatic. Within the established range pipe of any desired diameter can be manufactured by using one small bending tool which is held by two nuts. The tool is quickly replaced by another when switching production to a different size of pipe.

The welding gap is automatically adjusted and held constant. Adjustment can be made to an accuracy of 0.0025 in.

The machine is equipped either with a single-electrode, submerged-arc welding head or, if desired, with twin welding heads. Alternatively the machine can be made adaptable to high-frequency resistance welding. The company responsible for the *Heliweld* process is Intercontinental Enterprises, Düsseldorf. **CPE 1395**

They are stocking rayon hose

For conveying oil, grease, solvents, chemicals, spray and air, a new rayon yarn reinforced hose is available in sizes from $\frac{1}{2}$ in. (working pressure 475 p.s.i.) to $1\frac{1}{2}$ in. (135 p.s.i.). It is of standard two-braid construction and it is claimed that, while very flexible, it will do much of the work of three-braid cotton hose. Makers are B.T.R. Industries Ltd. **CPE 1396**

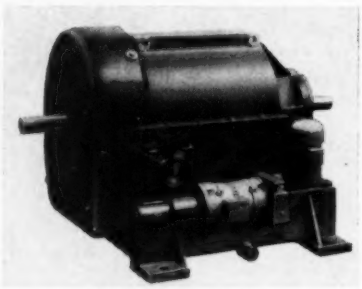
All-plastic valve

A wedge-gate, all-plastic valve is offered by Barflo Ltd. in pipe sizes from 1 to 3 in. It is available in several types of rigid plastics and is supplied with flanged or screwed fittings. Larger sizes are being developed. **CPE 1397**

For laboratory mix-ups

A general-purpose laboratory mixer introduced by Silverson Machines (Sales) Ltd. consists basically of a centrifugal suction pump enclosed in interchangeable heads and meshes. Rotor blades subject liquids to intense shear at high velocities, giving rapid and thorough processing. The manufacturers claim that emulsor meshes assist processing, break down agglomerates, remove oversize particles and produce homogeneous emulsions and dispersions rapidly.

The motor is enclosed in a chromium-plated casing together with a rheostat, controlled by a knob on top of the casing, and gives speeds of from 200 to 8,000 r.p.m. under load. A separate on/off switch is also fitted. All working parts are in stainless steel. **CPE 1398**



Variable-speed gear.

Slow-speed hydraulic motor.

Plenty of drive

A smooth, stepless range of output speeds from input speed down to about 25 r.p.m. is provided by a new variable-speed gear from Carter Gears Ltd., which may be used to pick up loads from zero r.p.m. It may be driven in either direction of input rotation and, if specially ordered, a reverse drive of up to 5% of input speed can be provided without reversal of the driving motor. Full reverse speed range can be obtained by reversing the input rotation.

This unit incorporates a torque-sharing, positive-displacement, hydro-mechanical design ensuring maximum power transmission efficiency by the direct mechanical transmission of part of the power at all output speeds.

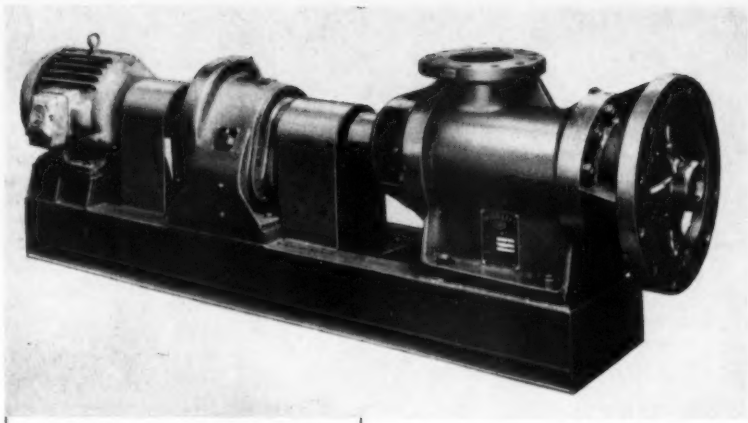
Handwheel and remote electrical controls are available as standard for fitting at either side of the gear. Speed-setting adjustments may be made with the drive either running or stationary. Output speed/control movement relationship is approximately linear. **CPE 1399**

High-vacuum still

For the distillation of heat-sensitive materials, a 2-in. molecular still is available comprising a glass feed flask, evaporator with heating mantle, cold trap and collecting flask, all mounted in tubular-steel framework with vacuum pumps and gauges. The rotary pump is mounted on the floor below the framework as are the vacuum gauge and heater control units, although for convenience these cabinets would normally be raised to bench height.

The glass feed flask has a capacity of 500 ml. and is provided with a degassing tube which allows controlled degassing and stripping of low-boiling contaminants before starting distillation.

The evaporator consists of a 2-in.-diam. glass column having a heated length of approximately 8 in. and total surface area of 50 sq. in. The wiper assembly incorporates three slotted blades which rotate at 120 r.p.m., thus distributing the incoming feed in a continuous and thin highly turbulent film. The whole wiped length of the evaporator is covered externally by an electrically heated mantle. Temperature measurement is provided by a thermocouple placed close to the heat-



FOR VISCOUS FLUIDS

Very large inlet ports, which are on a common axis to the screws and ensure the easy flow of very viscous fluids are a feature of a new type of pump by Mirrlees (Engineers) Ltd. This employs the Imo *screw-thread form and there are no cavities inside the pump to trap and hold fluid. High suction lifts can be achieved and there is no pulsation or emulsification of the fluid.*

CPE 1400

ing element and the maximum operating temperature of the heater is 450°C.

The incoming feed is exposed to the heated surface for approximately 10 sec., an average film thickness of between 0.01 and 0.005 in. being obtained, although this figure is dependent on viscosity of the crude feed. The stripped fractions pass up the evaporator body and condense into the cold trap, whilst low-boiling fractions which do evaporate condense on the water-cooled condenser inside the evaporator and drain into the distillate flask. The same range of high-vacuum stills by Edwards High Vacuum Ltd. also includes a 4-in. and a 12-in. model. **CPE 1401**

Do-it-yourself radiation processing

Self-contained and simple to operate, a new γ irradiation cell is suitable for laboratory experiments and small-scale radiation processing. According to the manufacturers, remote handling is not necessary and no radiation hazard can occur as a result of mishandling.

The radiation source consists of a ring of Cobalt-60 rods, mounted around a stainless-steel cylinder which is embedded in a shielding block. The cylindrical sample chamber is loaded and unloaded above the source, into which it is moved by a motor. The sample volume is 6 in. diam. $\times$ $8\frac{1}{2}$ in. high. The irradiation dose rate with a 1,100-curie source is approximately 10^5 roentgens/hr. The maximum source strength will depend on working conditions near the cell and will be between 13,000 and 30,000 curies, giving a maximum dose rate of about 2×10^6 roentgens/hr.

Samples may be irradiated for a pre-set time, adjustable between 18 min. and 120 hr., and the remaining irradiation time is indicated if for any reason irradiation is stopped before the desired period is completed.

Four ducts connected to the sample chamber allow the entry of pipes carrying liquids or gases and wiring, thus enabling irradiation in a controlled atmosphere to be achieved.

Built by Atomic Energy of Canada Ltd., this equipment is marketed in the U.K. by Watson & Sons (Electro-Medical) Ltd. **CPE 1402**

Reinforced resin

Production of a new fluorocarbon TFE-base resin, comprising PTFE and other specially developed constituents, improving the mechanical and thermal properties of PTFE without materially affecting its electrical and chemical characteristics, has been announced by Polypenco Ltd.

The coefficient of thermal expansion of *Fluorosint* is approximately one-sixth that of PTFE and is similar to aluminium, copper and a number of other metals. Dimensional tolerances can be held to limits that are one-third to one-sixth those of PTFE. It is free of stresses and parts do not distort on thermal shock or temperature cycling. Hardness is increased and creep or cold flow greatly reduced. Bearings can operate at much higher loads and speeds.

Fluorosint is available in rod or tubular form and can be specially moulded. **CPE 1403**

Fill in and post the reply-paid card for details of any items in these pages, making sure to quote the correct 'CPE' reference number.

Makes them go hot and cold

A new heat-transfer medium called *Thermex* is claimed to possess a combination of physical properties which makes it particularly suitable for liquid-phase and vapour-phase heating and cooling in a variety of industrial processes. It has a high boiling point (255°C.) and low freezing point (12°C.) and excellent thermal stability over long periods at temperatures up to 400°C. It has high heat-transfer coefficients, particularly in the vapour phase; further, it is non-corrosive and presents a negligible fire risk.

At high temperatures, *Thermex* operates at low working pressures. For instance, at 250°C., when steam is at a gauge pressure of 565 p.s.i., *Thermex* is still in the liquid phase and at atmospheric pressure. At 350°C., the gauge pressure of steam is 2,385 p.s.i., whilst the comparable pressure of the transfer medium is only 80 p.s.i. Furthermore, in vapour-phase heating, very accurate temperature control may be achieved simply by regulating the pressure. A single *Thermex* boiler may be used simultaneously for several different consuming points by adjusting the pressure at each point to give the desired temperature.

Typical examples of industrial processes in which the new medium can be used are: the melting and spinning of synthetic fibres; the distillation and processing of fats, vegetable oils, petroleum fractions and other high-boiling products; the concentration of sulphuric acid and caustic soda solutions; the processing of plastics and rubber products by extrusion and moulding techniques; and the manufacture of paints and varnishes.

Made by the Heavy Organic Chemicals Division of I.C.I., *Thermex* is a eutectic mixture of diphenyl oxide and diphenyl in the respective proportions by weight of 73.5 and 26.5%.

CPE 1404

A quarterly summary of recent happenings in the United States

American business investments in production plants overseas may well be a key to future relations with other nations if those facilities are operated in conformity with the public welfare of the host country. This was said by Mr. W. S. Carpenter, general manager of the Du Pont Co.'s international department, when he addressed the 46th National Foreign Trade Convention in New York.

The establishment of overseas operating policies requires a high degree of open-mindedness and flexibility and it is both necessary and desirable to employ a high percentage of local residents and create opportunities for them. Personnel temporarily transferred from the U.S. should be reduced at an early date, turning over the operation of the business, as far as possible, to local residents.

In choosing a product to be manufactured overseas, a major consideration must be the contribution that product can make to the economy in which it is to be produced. Those products that do not need heavy importation of raw materials and ones that provide business opportunities for local enterprises can bolster economies in other countries.

$

A new ' twin test loop ' is being used to test ' canned ' motor pumps at the atomic equipment department of Westinghouse Electric Corporation. Fluids at temperatures up to 500°F. can be pumped through the new unit which supplements existing high-temperature test loops operating at a greater temperature and pressure range. With the new loop it is possible to test the full line of canned motor pumps without changing the basic pattern of the loop. Previously it was necessary to make special modifications to the loop before testing various sized pumps. Also, this loop is designed for double-discharge piping—that is, the liquid may be circulated by means of two outlets on the pump, thereby affording more accurate and complete testing.

The canned pumps were designed by Westinghouse to eliminate radioactive pump leakage in atomic electric generating plants and aboard nuclear-powered vessels. Both the stationary outer coils and the rotating portion, or rotor, are canned in metal to ensure no fluid contact with electrical components.

$

More and more manpower and money has been devoted to the *Sherwood* thermonuclear research project over the past three or four years and, at the end of the present fiscal year, about $105 million will have been invested in this research at four principal laboratories, and several smaller ones will have some 330 scientific people devoted to this work. And yet, so difficult is this problem that the first important objective—that of igniting a controlled thermonuclear reaction on a laboratory scale—has not yet been arrived at.

As was pointed out by Mr. J. H. Williams, Commissioner, U.S. Atomic Energy Commission, at a recent meeting of the American Petroleum Institute in Chicago, this means that thermonuclear work has not yet reached the same stage of development as the fission programme had reached on December 2, 1942, when the first chain-reacting system was achieved.

It would be proper to characterise the achievement of a controlled thermonuclear reaction as possibly an order of magnitude more difficult than for the fission process. There have been flurries of optimism that thermonuclear reaction had indeed been achieved in the laboratory, though not on a self-sustaining basis. Mr. Williams felt that this first objective might be reached within the next two to five years. Conversely, no one believes that there will be a really dramatic breakthrough in technology. It will be a gradual process of trial and error, followed by detailed and complex analyses. ' When we understand the facts better, we may, indeed, be able to look back to an earlier point in time and realise that controlled thermonuclear reaction had already been achieved.'

The first goal which must be achieved, mentioned above, is to bring the nuclei participating in the reaction to the ' ignition ' temperature, at which point the energy input will just equal the losses by radiation. The second goal will be to build a machine or reactor which will have a net power output on a sustained basis. Some way must also be found to convert the energy of fusion into mechanical or electrical power. The accomplishment of this end may well be 15 to 20 years away.

$

The increasing employment of ' packaged ' plant and equipment as aids to manufacturing economy has had its effect on the chemical industry with the introduction of improved processing methods. Packaged boilers best exemplify the idea of a small, independent plant, but the idea of a unitised group of apparatus can be seen by a number of single-purpose units of other kinds, such as motor-driven pumps and other machines, mills and pulverisers teamed up with separators and feeders, and various other tandem arrangements. Packaging equipment itself is packed, complete units being available to weigh, fill and label automatically and continuously.

This trend was evident at the 27th Exposition of Chemical Industries, held in New York recently, while

another feature of the exhibition was the heavy emphasis placed on more highly resistant chemical processing equipment. Here one can also see the coincidence of nuclear energy industry needs with those of the chemical industry. An acid valve, used in atomic plants as well as in oil refineries and chemical works, was one example. A nuclear waste evaporator for reactor containment vessels was another.

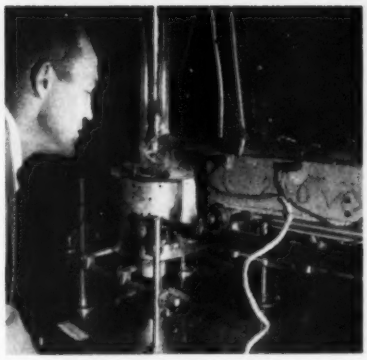
Gases for laboratory and small-production needs are customarily fed from cylinders, but the cost of tank gases mounts as consumption increases. A high-purity gas generator was offered to the consumer whose needs are below the bulk market. Important applications in the low-volume range for hydrogen include hydrogenation of animal and vegetable oils, production of metal hydrides, aniline and nylon, annealing of metals, powder metallurgy and transistor manufacture. The equipment offered for such uses, in capacities of 1,000 to 10,000 cu.ft./hr., is completely instrumented for continuous operation. The purified hydrogen output is said to have a dewpoint of –100°F.

In another field, centrifugal molecular stills in production capacities were introduced at the Exposition. Similar equipment has long been used in laboratory and pilot-plant applications; the innovation is in continuous production models at hourly throughputs of 400 to 4,000 lb. Principal applications are in separations of organic and silicone compounds in the molecular weight range of 250 to 4,000, including fatty acids, waxes, vegetable oils, epoxy resins, petroleum greases, tall oil and many pharmaceuticals.

Carbon and graphite products included a new type of glove valve and a modular entrainment separator, along with other carbon fabrications to handle any unit operation where corrosion is a problem. *Carbon Wool*, a new form of elemental amorphous carbon in fibre form, is another newcomer. It is available in seven standard grades.

For temperature testing and conditioning volatile or inflammable samples there was a safety oven in which the heating surfaces are arranged to avoid work-load ignition, and ventilation prevents the build-up of dangerous pressures, while an explosion head at the rear would be safely released into a stout steel cage in the event of a detonation of dangerous gases.

A new and inexpensive *Thermo-Balance* for recording thermogravimetric curves of samples in controlled atmospheres up to 1,100°C., and a new instrument for measuring the plasticity of coal, ceramics, inorganic polymers and other materials at temperatures up to 650°C., will also be disclosed. A new continuous level indicator for remote installation features two-step calibration and a built-in test circuitry.



ULTRA-PURE CRYSTAL

This apparatus was used to produce an indium antimonide specimen, to be used in low-temperature transistors and infra-red detectors, which is claimed to represent the purest crystal ever made of any compound. Its 99.999999+ purity was obtained through the use of unique equipment developed at the Columbus, Ohio, research centre of Battelle Memorial Institute, in connection with research carried out for the Air Force Office of Scientific Research. Without removal from the apparatus, the indium antimonide was first zone-refined in the horizontal quartz tube, then poured into the furnace crucible, after which the crystal was pulled in the vertical glass column. Crystals such as this are being used by Battelle research workers to study basic properties of the material for the A.F.O.S.R. and to investigate uses of indium antimonide in galvanomagnetic devices for the Electronic Components Laboratory of Wright Air Development Center.

\$

The method of 'least squares' is used extensively by physicists, chemists and engineers for the fitting of theoretical or empirical curves to experimental data. In the simplest, and perhaps the most common, of these curve-fitting situations the experimental points representing the data fall along an approximately straight line. However, for the accepted statistical fitting formulae to be valid in this instance, the data must satisfy certain requirements. The most important of these is that the experimental errors affecting various points be mutually independent.

As this condition is very frequently violated, the National Bureau of Standards has made a study of the fitting of straight lines to *cumulative* data. This work by J. Mandel has shown that, if data subject to cumulative types of error are treated by the ordinary formulae of 'linear regression,' the true fluctuations of the process as well as the uncertainty in the estimated rate of the process are seriously underestimated.

Theoretical studies have shown that, for the case of equidistant spacing along the axis of the independent variable, the application of the ordinary 'least-squares' formulae to data with cumulative-type errors leads to an estimate of the standard error of the slope that is too small by a factor of $2\sqrt{N}$, where N is the number of points. Thus for 50 equally spaced points the slope would be estimated to be 14 times more precise than it actually is. Fortunately, with at least 30 points the data themselves readily betray their cumulative nature. Unlike independent measurements, data with cumulative errors show long series of successive points, all of which are on one side of the fitted line.

A criterion for judging whether the situation under consideration involves independent or cumulative data can therefore be based on the number of times the line joining successive observations crosses the fitted line. When data are cumulative the number of intersections is, of course, relatively small.

This theory has been applied to the results obtained in a study of the relation between mechanical stress and double refraction in optical glasses. A graphical representation of this relation indicated that the experimental errors were predominantly cumulative. Data were therefore treated accordingly, and an overestimation of the precision of experimental findings was avoided.

\$

The Chemicals Division of Olin Mathieson Chemical Corporation is planning to further expand its electrolytic caustic-chlorine plant at McIntosh, Ala.

The initial installation at McIntosh was in 1952. The plant was doubled by the addition of a second unit which was completed in early 1957. It is proposed to add a new cell bank to the two already installed. The projected expansion is to meet the needs of the customers in the mid-south, particularly the rayon and the pulp and paper industries.

Company News

Courtaulds Ltd. have decided to reopen part of Aber Works, Flint, which was closed in December 1957, for the manufacture of bleached sulphate pulp for the paper and board industries.

Plans are now in hand for the installation of machinery and plant. Initial output will be of the order of 50,000 tons p.a. and production is scheduled to start towards the end of 1960.

*

Capacity for the production of *Courtelle* acrylic fibre, now 10 million lb. p.a., is to be doubled at the Grimsby factory of Courtaulds Ltd. The extension will be accommodated on the 500-acre site at Grimsby where rayon staple is also produced. The new plant is scheduled to come into production early in 1961.

*

Following recent price cuts to a range of solvent products, Shell Chemical Co. Ltd. announce price reductions of up to £10/ton for more of their industrial chemicals.

Most of the company's range of alkanolamines and both grades of monopropylene glycol are affected.

*

This year the George Cohen 600 Group is 125 years old—or, more accurately, it is a century and a quarter since George Cohen founded, in 1834, a modest business in London for ' the purchase and sale of scrap cast and wrought iron.' Today the group has a turnover of some £30 million p.a., has over 30 subsidiaries and employs assets of about £17 million. Among its major activities the group manufactures mobile cranes, lathes, steel castings, roller bearings and iron castings.

The group is proud of the friendly relations between management and employees and that the group were among the first—if not *the* first—to introduce an employment security scheme whereby any man found redundant receives, in addition to his normal week's notice, one week's money for every year of service. The group employs 8,000 people, of whom some 500 have more than 25 years' service.

*

The second petrochemical plant of Union Carbide Ltd. at Hythe, near Southampton, is nearing completion. Ethylene from Esso's adjacent refinery will be converted into ethylene oxide derivatives, to provide about 45 million lb. p.a. of petrochemicals. Installations include units for the production of ethylene oxide, ethylene glycols, polythene glycols, ethanolamines, glycol-ethers and specialised products including polyglycol ethers, polyglycol esters, and other surface-active agents.

*

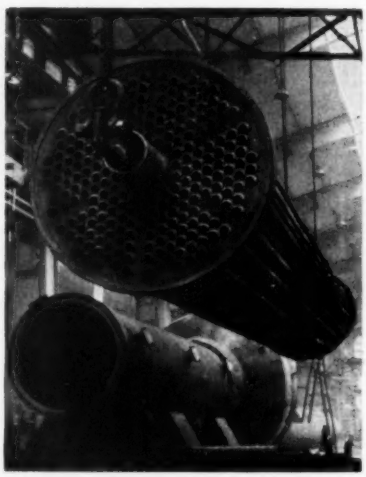
Dobeckmun Britain Ltd., the British subsidiary of the Dow Chemical Co. of Midland, Michigan, U.S.A., has changed its name to Dow Chemical Co. (U.K.) Ltd. and broadened the scope of its activities. It will take over direct sales of Dow-produced packaging films and will also supervise the sales of Dow U.S.- and Canadian-produced industrial chemicals, plastics and magnesium in Britain.

I.C.I. are extending their production of semi-conductor grades of silicon to cover zone-refined silicon in rod form. Lump silicon is the form that the company have been marketing successfully so far, but they have been investigating methods of growing silicon rods suitable for zone-refining, and are now installing a new plant which will be producing polycrystalline rods early in 1960.

The rods will be up to 1 in. diam. and up to 24 in. long. They will have a smooth surface finish and it is stated that this, together with their very small variations in physical dimensions, will enable them to be used without further processing in zone-refining equipment. It will be possible to obtain high-quality single-crystal rods after a few passes in the zone-refiner.

Orders and Contracts

Following a recent order for a second sinter plant to be installed at Aviles in Spain, Head Wrightson Iron & Steel Works Engg. Ltd. are now engaged with the building of an iron ore sintering plant at the Clyde Iron Works, of Colvilles Ltd. in Glasgow.



BOILER FOR LURGI PLANT

A tube bundle ready for sleeving in the shell of a waste-heat boiler in the Stockton works of Ashmore, Benson, Pease & Co. Ltd., where this and other equipment is being manufactured for P.G. Engineering Ltd., the Power-Gas subsidiary which is handling this part of the construction work for the Lurgi high-pressure gasification plant of the Scottish Gas Board at Westfield, Fife. An agreement for the construction of the plant was made last year between Lurgi Gesellschaft für Warmetechnik mbH. and Humphreys & Glasgow Ltd., in association with the Power-Gas Corporation Ltd.

The plant will be one of the largest single-strand sintering units to be built in Britain and will be capable of producing 2,500 tons/day of blast furnace sinter. The value of the order is approximately £700,000.

The plant is expected to go into commission about the middle of 1961 and is the second of this type which Head Wrightson have supplied to Colvilles Ltd.

The present order represents the tenth complete sinter plant and includes the nineteenth sinter machine to be ordered from Head Wrightson in the past ten years. Head Wrightson are carrying out a continuous programme of research into sinter machine design in collaboration with Arthur G. McKee of Cleveland, U.S.A.

*

William Boby & Co. Ltd., water treatment engineers of Rickmansworth, Hertfordshire, have been awarded a contract by Courtaulds Ltd. for a complete fully automatic demineralisation plant for a new Russian synthetic fibre factory.

*

A nitrogen fertiliser plant is to be built at Shiraz by the French company E.N.S.A. for the Iranian Government. Société Belge de l'Azote et des Produits Chimiques du Marly (S.B.A.) at Liège (Belgium) has been entrusted with the design of the nitric acid and ammonium nitrate producing plant, according to an agreement concluded between this company and the general contractor, E.N.S.A. Co. (France). The Foster Wheeler Française Co. will handle the general engineering of this project.

World News

INDIA

Caustic soda project

Approval has been given for the building of a 4,000-ton caustic soda plant at Tanuku in Andhra Pradesh. Machinery and equipment worth £275,000 will be bought from East Germany. Production of caustic soda was recently begun at the Dhrangadhra Chemical Works Ltd., Tiruneveli District, Madras State. This plant has a rated capacity of 30,000 tons p.a., using the electrolytic process, and is claimed to be the largest of its kind in south-east Asia. Output at present is at the rate of 25,000 tons p.a.

BELGIUM

New steelworks

The new basic Bessemer steelworks at Ougrée has been inaugurated. It is equipped with five 50 to 60-ton converters with possibilities of adding a sixth, and two mixers having a capacity of 1,500 tons of molten metal. Its productive capacity from next year will be 1.5 million tons of steel p.a.

The plant occupies an area of 21,000 sq. m. and represents an investment of B.Fr.6,000 million. Most operations are fully automatic and controlled by a series of electronic calculators.

One of the most remarkable features of the new plant is that it has been built in three years around the existing Cockerill-Ougrée steelworks at Ougrée without any stoppage of current production.

TRINIDAD

Chemicals, fertilisers and plastics

The 'Grace' subsidiary, Federation Chemicals Ltd., whose initial factory in Trinidad for the manufacture of fertilisers is over 60% completed, expects to have one of its four plants in operation by the end of 1959. This will be the ammonia plant, which will produce approximately 40,000 tons p.a. The other three plants will produce sulphuric acid, sulphate of ammonia and urea.

In addition, the company have been granted 'pioneer status' for the production of styrene monomer. Production is expected to be some 45 million lb. p.a. of monomer.

NETHERLANDS

Fertilisers from natural gas

An agreement has been made between the Netherlands State Gas Industry and the Royal Netherlands Blast Furnaces & Steelworks for the daily supply of 7 million cu. ft. of natural gas from the oil wells in the west. The gas will be piped to Ijmuiden 50 miles away and used chiefly by N.V. Maatschappij tot Exploitatie van Kooksovengassen for the production of nitrogenous fertilisers. Production is expected to start at the end of 1960.

Phenol

The N.V. Koninklijke Zwavelzuurfabrieken v/h Ketjen (Royal Sulphuric Acid Works) is to build a new factory to produce phenol. Initial capacity will be 2,000 to 3,000 tons p.a., which the company will consume itself, but capacity may be doubled or even trebled later. Building costs are estimated at fl. 10 million, to be financed from the company's own resources.

AUSTRALIA

Ferro-manganese plant

The Broken Hill Proprietary Co. Ltd. is to establish an electro-metallurgical industry in Tasmania. It will be at Bell Bay and will adjoin the factory of the Australian Aluminium Corporation. Initially the plant will produce ferro-manganese, an alloy used in steel-making. Production is scheduled to begin early in 1962. The plant will cost £A1.6 million. Production of ferro-manganese will mean an immediate saving in Australia's overseas exchange of at least £A1.5 million a year.

HUNGARY

Caustic soda plants

Komplex Trading Co. of Budapest recently bought complete equipment for two caustic soda plants from Krebs Cie. of Paris. One of the plants is to be installed at the Hungaria Chemical Works, Budapest, while the other will go to Berente in north-east Hungary. The value of the equipment is about $2 million. The annual capacity of each caustic soda plant is approximately 10,000 tons. The plant at Hungaria works is scheduled to go into operation in the first quarter of 1962, while the one for the Berente works is to be operated by the second half of the same year.

Leonard Hill in Kenya

Mr. W. Leonard Hill, chairman of Leonard Hill Ltd. (publishers of CHEMICAL & PROCESS ENGINEERING) will be visiting Kenya in January and February. He arrives in Nairobi on January 14 and will stay for four to six weeks. He intends to study agricultural and industrial affairs in Kenya and will be pleased to meet Kenya readers of CHEMICAL & PROCESS ENGINEERING.

He can be reached through Group Capt. C. G. Briggs in Nairobi or Poste Restante, G.P.O., Nairobi.

NEW ZEALAND

£2 million paper mill scheme

New Zealand Forest Products Ltd. proposes to build a pulp and paper mill in Canterbury with an initial outlay of £2 million. Other companies in the New Zealand paper industry will be invited to share in the project. Forest Products is prepared, however, to finance the scheme itself. The mill could be in production within three years of a licence being granted.

The company has a third paper mill on order in Britain for its Kinleith works, in the North Island, and if necessary this could be diverted to Canterbury and a further order then be placed for Kinleith.

SOUTH AFRICA

Atomic energy and uranium

Dr. A. J. A. Roux, director of the Atomic Energy Board's £4-million research and development programme, told a meeting of the South African Institute of Mechanical Engineers in Johannesburg that, instead of buying an atomic reactor of high flux costing about £1.5 million, the Board proposed to buy a cheaper one and then build its own reactor of an adequate size. He said the objects of the development programme were to ensure that the country derived the maximum benefit from the fact that it was one of the three largest producers of uranium in the world; to enable the Union to make a contribution to the vast and important field of atomic research and development; and to assist the young and vigorous South African industry gradually and systematically to orientate itself to the new technology associated with atomic power.

It was necessary, he said, to improve methods of mining and extracting uranium so as to strengthen the Union's position in a competitive market. Thorium was the only alternative source of nuclear fuel and the Union, probably the largest thorium producer in the world, should be prepared for a demand.

★ Personal Paragraphs ★

★ **Mr. L. E. Whitmore** becomes director and general manager, Polyethylene Division, of Union Carbide Ltd., with responsibility for marketing, manufacture, etc. **Mr. J. F. Widman,** previously director of marketing, chemicals, becomes director and general manager, Chemicals Division. He will be responsible not only for the manufacture and sale of products from the new plant at Hythe but also for continued development of the market for imported chemicals. **Mr. R. Wilson** has been appointed a director of the company and becomes director and general manager, Alloys Division.

★ **Mr. J. A. Hepworth** has been appointed Chief Engineer of the North Thames Gas Board as from January 1. He succeeds **Dr. J. Burns** who becomes Deputy Chairman of the Board. Mr. Hepworth joined the former Gas Light & Coke Co. in 1922 as a junior assistant engineer at Beckton gasworks. He is senior vice-chairman of the London and Southern Section of the Institution of Gas Engineers.

★ **Mr. H. P. Forder** and **Mr. A. R. Hay** have been appointed directors of the United Steel Cos. Ltd. Mr. Forder is director and general manager of a subsidiary, Samuel Fox & Co. Ltd., and Mr. Hay is a director of the subsidiary, Naylor, Benzon & Co. Ltd.

★ **Adml. Sir Michael M. Denny,** G.C.B., C.B.E., D.S.O., has been appointed a director of English Steel Corporation Ltd.

★ **Mr. J. C. Weyrich** has been appointed manager for Du Pont's Maydown works at Londonderry, Northern Ireland. Before his new appointment, he held various supervisory and managerial positions in the company's two neoprene synthetic rubber plants in Louisville, Kentucky, and Montague, Michigan, in the United States. In January 1959 he was transferred to Wilmington, Delaware, as project manager for the Londonderry neoprene works.

★ **Mr. T. G. Ellison** and **Mr. A. E. Skan** have been appointed joint managing directors of George Ellison Ltd. Mr. Ellison is a son of the founder of the company, the late Mr. G. Ellison, and has been a director since 1929. He was elected chairman of this and of the associated companies, Alfred Ellison Ltd. and Tufnol Ltd., in 1955. Mr. Skan has been a director of all three companies since 1944 and is managing director of Tufnol Ltd. He is a past-chairman of the British Plastics Federation.

★ **Prof. C. F. Carter** has been appointed a member of the Council for Scientific and Industrial Research. He takes the place of **Prof. E. A. G. Robinson,** who retires on completion of his period of service. Prof. Carter is Stanley Jevons Professor of Political Economy and Cobden Lecturer in the University of Manchester.

★ **Mr. T. Haas** has been appointed head of the design section in the newly-formed members' service department of the British Welding Research Association. For the past six years he has held the position of head of the fatigue department of the Bristol Aircraft Co. at Filton.

★ As a result of a group reorganisation the board of the Chemical & Insulating Co. Ltd. has been reconstituted as follows: **Mr. D. J. Grant** (chairman), **Mr. F. R. Gibson** (managing director), **Mr. G. Banks, Mr. K. C. Plumbe** and **Mr. F. Sawdon.**

£ s d

CHEMICAL PLANT COSTS

Cost indices for the month of October 1959 are as follows:

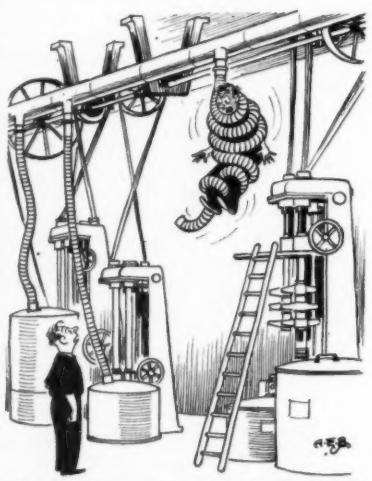
Plant Construction Index: 178.8

Equipment Cost Index: 166.2

(June 1949 = 100)

£ s d

Comical Engineering Corner



'DON'T JUST STAND THERE, MAN — DO SOMETHING!'

Pure metals by electron-stream melting

Europe's first electron-stream melting furnace working on an industrial scale has recently been brought into production by the German Degussa concern.

The furnace is distinguished from existing vacuum furnaces mainly by the type of heating. A tungsten cathode emits electrons which are accelerated by means of a high voltage of approximately 12,000 v. They thus attain speeds of about 40,000 miles/sec. and acquire, in spite of their small size, a high kinetic energy which is converted into heat when the electrons hit the material to be treated, and causes it to melt.

With this furnace, it is possible to purify metals with a high melting point, such as tungsten, tantalum, molybdenum, niobium, etc., to a degree hitherto unknown. The process is carried out under high vacuum at pressures of 10^{-5} Torr, and reduces the undesirable impurities to lower values than is possible with vacuum sintering or vacuum arc melting. As a result, the material thus purified is distinguished by properties which it has, so far, not been possible to attain with any other method. It is very likely that the method will also prove to be suitable for the purification of non-metallic materials.

Of interest to our readers . . .

A number of articles appearing in our associate journals this month will appeal to readers of CHEMICAL & PROCESS ENGINEERING.

The Manufacturing Chemist has a review of chemical and other pumps. D. P. Hopkins contributes an authoritative progress report on fertilisers and plant nutrients.

Petroleum reviews British refineries and has an article dealing with petrochemicals from the Belayim coking unit.

Fibres and Plastics. There are articles on reinforced plastics dealing with production, gel coats and resins.

Automation Progress contains an article on transfer machining of graphite for nuclear piles.

Corrosion Technology has an article on aluminium in refineries, while a number of other articles and notes are of interest to chemical engineers.

Paint Manufacture. The many uses of glycerol alkyds is the subject of one article, while another is the fourth in a series on advanced paint chemistry. This issue also includes a pull-out chart giving a comprehensive guide to resins.

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